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TABLE OF CONTENTS

Vol. 19 April, 1936 No. 4

THE JOURNAL OF THE AMERICAN CERAMIC SOCIETY

Further Data on Enamel Adherence 93
By Karl M. Kautz

Effect of Mill Additions on the Thermal Expansion of Sheet-Iron Ground-Coat Enamels 109
By R. L. Fellows and E. E. Howe

Some Experiments in the Development of a Sand-Abrasion Machine 112
By G. H. Spencer-Strong

The Plasticity of Finely Ground Minerals with Water 115
By Earl O. Wilson

Influence of Drying Treatment and Biscuit Storage Atmosphere on the Physical Properties of a Semiporcelain Body 121
By H. L. Latimer and Arthur S. Watts

CERAMIC ABSTRACTS

Vol. 15 No. 4

Abrasives 111
Art and Archeology 112
Cements 114
Enamel 116
Glass 117
Structural Clay Products 123
Refractories 124
Whiteware 126
Equipment and Apparatus 126
Kilns, Furnaces, Fuels, and Combustion 129
Geology 130
Chemistry and Physics 133
General 135

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CLAY GLASS ENAMELS

FURTHER DATA ON ENAMEL ADHERENCE*

By Karl Kautz

Abstract

Experiments designed to test the theories of gripping and electrochemical displacement as factors in the adherence of enamels to metals were performed. Rough surfaces on chromium, the stainless steels, and nickel produced no better adherence than smooth surfaces. Rough and smooth surfaces on iron enameled *in vacuo* and in nitrogen gave extremely poor adherence. Gripping action apparently functions on enameled noble metals.

Poor adherence on chromium, a metal higher than cobalt in the electrochemical series, and good adherence on copper, a metal below cobalt in the series, tend to show that electrolytic reactions, if they do occur, are not the fundamental cause of adherence. Enamels fired on iron *in vacuo* or in nitrogen are given the most advantageous conditions for electrolytic reactions to take place, yet the adherence in these cases is extremely poor.

Gripping action or electrolytic reactions could not function properly on oxidizable alloys and metals due to oxide layers which formed under the glass layer in firing. The importance of oxygen in enameling metals is emphasized by these experiments.

A brief review of the work of Pfeil, Castro and Portevin, and Mathewson, Spire, and Milligan on the constitution of iron scale is given. It is shown that metallic iron particles may exist in ferrous-oxide scale as true primary dendrites, as rounded grains of residual α-iron from the base, and as minute specks or thin layers of secondary α-iron.

Microscopic study of iron-enamel contact zones showed no true dendrites of iron to be present. In underfired enamels was found the α-iron phase from the initial scale, but in the scale underlying this enamel both residual α-iron phase and secondary α-iron were found. In normally fired enamels only detached surface iron produced by slow oxidation of the iron base surface was found. The iron surface and the detached surface iron particles after proper etching showed a film of ferrous phase approximately 3×10^{-3} inch thick between the glass and metal. This film of ferrous phase is believed to be the medium which bonds the enamel and iron together.

Microscopic study also showed the effect of an increased diffusion of oxygen as the enamel became richer in iron oxide. Cobalt oxide in the enamel is believed to promote solution of ferrous phase and also to act as an oxygen carrier through the molten glass layer.

A description of the six stages in the complete firing of cobalt ground-coat enamels on iron is given and also the reactions which occur in each stage.

I. Introduction

The nature of the adherence between vitreous enamels and iron has been in recent years the subject for many investigations and for the formulation of numerous theories. A complete review of the literature can not properly be given here, but the outstanding work of King and his co-workers,[1] Cooke,[2] Staley,[3] Clawson,[4] Vielhaber,[5] and Dietzel

* Received September 28, 1935.

[1] (*a*) W. C. Rueckel and R. M. King, "Mechanics of Enamel Adherence, II. Effect of Composition and Firing Atmospheres on Adherence of Ground-Coat Enamels," *Jour. Amer. Ceram. Soc.*, 14 [10] 782–88 (1931).

(*b*) W. K. Carter and R. M. King, "Mechanics of Enamel Adherence, III. Enamels on Copper: the Nature of Their Adherence," *ibid.*, pp. 788–94.

(*c*) G. H. Spencer-Strong and R. M. King, "Mechanics of Enamel Adherence, V. A Study of Enamel-Metal Contact Zones by Chemical Methods," *ibid.*, 15 [9] 480–83 (1932).

(*d*) K. Schwartzwalder and R. M. King, "Mechanics of Enamel Adherence, VI. A Petrographic, Metallographic and X-Ray Study of Enamel-Metal Contact Zones," *ibid.*, pp. 483–86

(*e*) G. H. Spencer-Strong, J. O. Lord, and R. M. King, "Mechanics of Enamel Adherence, VII. Further Studies on Enamel-Metal Contact Zones by Microscopic and Metallographic Methods," *ibid.*, pp. 486–90.

(*f*) R. M. King, "Mechanics of Enamel Adherence, VIII. (*B*) Studies in Firing Enamels under Reduced Pressure," *ibid.*, 16 [5] 233–38 (1933).

(*g*) G. H. Spencer-Strong and R. M. King, "Mechanics of Enamel Adherence, IX. Equilibrium Studies in Some Systems of Enamel Glass and Cobalt, Nickel, and Iron Oxides," *ibid.*, 17 [7] 208–14 (1934).

(*h*) R. M. King, "Mechanics of Enamel Adherence, X. The 'Iron Oxide Layer' in Sheet-Steel Ground Coats," *ibid.*, pp. 215–19.

[2] (*a*) R. D. Cooke, "Effect of Furnace Atmosphere on the Firing of Enamel," *ibid.*, 7 [4] 277–81 (1924).

(*b*) R. D. Cooke, "Making and Firing of Sheet-Steel Ground Coats," *ibid.*, 10 [6] 454–56 (1927).

[3] H. F. Staley, "Electrolytic Reactions in Vitreous Enamels and Their Relation to the Adherence of Enamels to Steel," *ibid.*, 17 [6] 163–67 (1934).

[4] C. D. Clawson, "A Study of Adherence of Ground Coats to Sheet Steel," *Ceram. Ind.*, 13, 164 (1929); *Ceram. Abs.*, 8 [10] 710 (1929).

[5] L. Vielhaber, "Behavior of Metal Oxides in Ground Coats on Sheet Steel," *Ceram. Ind.*, 4, 371 (1925); *Keram. Rund.*, 33, 53–55 (1925); *Ceram. Abs.*, 4 [6] 156 (1925).

and Meures[6] deserves special mention. Unquestionably more fundamental knowledge of the mechanics of vitreous enamel adherence to metals, particularly iron, should go far toward advancing the art of vitreous enameling and the development of better enamel frits and enameling iron sheets.

It is extremely difficult to classify or simplify the many theories of adherence due to overlapping tendencies. They may, however, be divided roughly into four groups.

(1) The gripping theory maintains that enamel glass is held to the metal by inclosing the projections and filling the depressions occurring on the metal surface.

(2) The electrolytic theory is based upon the supposition that iron, being higher in the electrochemical series of the elements, will displace or plate out cobalt and nickel in solution in the ground-coat enamels. These plates of cobalt and nickel adhere to the iron; the enamel glass is mechanically bonded to the metal plates by gripping and by dendrites.

(3) The dendritic theory contends that tiny, tooth-like crystals of α-iron, or ferrite, are crystallized from the solution of iron oxide in the glass and become attached to the iron base, thus literally "spiking" the glass to the base in numerous places.

(4) The oxide-layer theory maintains that the glass is held to the iron by an intervening layer of iron oxide.

It was the purpose of this investigation to test these four theories on a number of different metals under varied experimental conditions and to study, metallographically, the contact zones between metal and glass so that additional data on the adherence of ground-coat enamels to iron could be obtained.

II. Experiments Relating to Gripping and Electrochemical Displacement

In the following experiments, customary enameling practice was followed except where noted. Commercial ground-coat enamels, containing the usual manganese, cobalt, and nickel compounds in solution, were fired at 1600°F until properly matured, using a Hoskins electric resistance-type furnace.

One-half of each sample was roughened either by sandblasting or by the use of very coarse emery cloth, and the other half remained smooth either by the original cold rolling or buffing.

(1) Chromium

Commercial ground-coat enamels did not adhere to pure chromium whether the surface was smooth or rough. When flexed, the enamel parted easily exposing bright clean metal underneath. The parted glass had a layer of green chromium oxide adhering on the metal side due undoubtedly to oxidation of the chromium surface. On pure chromium which had been preoxidized to a film of tightly adhering green chromium oxide, a stable and relatively good adherence was obtained, which was slightly greater on the roughened surface.

(2) Ferrochrome

An alloy of iron and chromium, containing 72% chromium, was ground to thin roughened plates. One was enameled as such and another was preoxidized before enameling. The enamel adherence could not be determined by the ordinary impact or flexure methods due to the hardness and rigidity of the material. By chipping with a sharp instrument, the enamel came off easily in large flakes on the unoxidized sample but adhered firmly to the preoxidized sample.

(3) Stainless Steels

A straight chromium stainless steel, containing about 15% chromium, was enameled as such and after preoxidizing. The adherence was very poor on the regular sample, no difference being noticed between the smooth cold-rolled surface and the sandblasted surface. There was a slight increase in the adherence upon preoxidizing, which was more pronounced on the sandblasted surface.

With stainless steel containing 18% chromium and 8% nickel, however, a marked increase in the adherence of ground-coat enamel was apparent. The preoxidized samples showed better adherence than the unoxidized, with the sandblasted portion the best. On the unoxidized sample, there was

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[6] (*a*) A. Dietzel and K. Meures, "Reactions Important for Adherence When Firing Ground Coats Containing No Adherence-Promoting Oxides," *Jour. Amer. Ceram. Soc.*, **18** [2] 35–37 (1935).
(*b*) A. Dietzel and K. Meures, "Adjustment of Enamels to Sheet Steel," *ibid.*, pp. 37–38.
(*c*) A. Dietzel, "Adherence in Sheet-Iron Enamelware," *Sprechsaal*, **68** [1] 3–6; [2] 20–23; [3] 34–36; [4] 53–56; [5] 67–69; [6] 84–85 (1935); *Ceram. Abs.*, **14** [5] 107 (1935).

only a slight difference in adherence between the smooth and rough surfaces.

(4) Iron

When enameling iron was coated with a commercial ground-coat enamel and fired *in vacuo*, no adherence was obtained either on a smooth or sandblasted surface. The enamel had a bubbled and wrinkled appearance, due probably to the escape of occluded gases from the iron, and shattered spontaneously or separated in large areas from the iron base. When iron was previously oxidized, however, and then enameled *in vacuo*, good adherence was obtained.

When commercial nitrogen, freed from the usual traces of oxygen and water-vapor, was used as the atmosphere in firing the commercial ground-coat enamel to the iron, a green colored enamel was obtained. The enamel ruffled or wrinkled in the center of the sample upon cooling but remained smooth near the edges. This confirmed the observations of Cooke[26] and was probably due to the difference in the rate of contraction of the glass layer and the iron upon cooling. Bare or uncovered portions of the iron showed the characteristic dark gray color due to nitriding at this temperature. When flexed, the enamel parted easily from the iron both on smooth and rough surfaces. When the iron was preoxidized, however, good adherence was obtained with ground-coat enamels in this nitrogen atmosphere.

Clean iron was suddenly plunged into a crucible of molten ground-coat enamel and allowed to remain four minutes before withdrawal. Excellent adherence was obtained on that portion in contact with the molten surface and air, but very poor adherence on that portion at the bottom of the crucible.

When enameling iron was completely oxidized and the scale enameled in the customary manner, very good adherence was obtained. Ground-coat enamel on iron scale acted like a glaze on a china body, producing a perfect "glaze fit."

(5) Nickel

When pure electrolytic nickel was enameled with a commercial ground-coat enamel, there was no adherence whatsoever. The enamel had a bubbled or wrinkled appearance and flaked off spontaneously when cold. Flakes of enamel which chipped off had a dark gray layer, possibly nickel oxide, adhering on the metal side. Neither a smooth, sandblasted, nor a nitric-acid etched surface produced adherence. If, however, the nickel was previously oxidized to a firm black oxide and then enameled, the enamel while still pitted and rough did not flake off spontaneously and it showed a fair degree of adherence upon flexing.

(6) Copper

When copper was enameled in the customary manner with a commercial ground-coat enamel, a fair degree of adherence was obtained. This was about the same whether a smooth, rough, or nitric-acid etched surface was used. When preoxidized, no difference could be seen in the degree of adherence. This may be due to the fact that copper is easily oxidized, first forming red cuprous oxide and later black cupric oxide. The black oxide has poor adherence to the red oxide and either flakes off or is easily rubbed off after oxidizing. Impact tests showed only red cuprous oxide in contact with the enamel in both unoxidized and preoxidized samples, probably due to its low solubility in the glass, while the black cupric oxide was readily taken into solution.

(7) The Noble Metals

No attempts were made to preoxidize the silver, gold, and platinum samples, as these are generally regarded as unoxidizable. Silver, when enameled with commercial ground-coat enamel in the usual manner, exhibited a remarkable degree of adherence. The glass could be separated by flexure or bending but not easily. Ground-coat enamels on gold crawled badly and pulled away from the edges. The adherence may be regarded as poor, since the metal being soft and ductile could easily be stripped from the enamel, leaving large sheets of the glass. Ground-coat enamels did not crawl on platinum as on gold, but they had poor adherence, and the metal could easily be stripped from the enamel layer.

III. Discussion of Experiments

Since these experiments were performed principally to test the gripping and electrolytic theories of enamel adherence to metals, a discussion of the results obtained as related to each theory is desirable.

The *gripping theory* maintains that the enamel is held to the metal by wetting the surface, filling

the depressions, and inclosing the projections so that it is rigidly held in place. It may be regarded as comparable to glue adhering to wood by penetration into the pores. The rougher the surface of the metal, therefore, the better would be the adherence.

In the above experiments with chromium, the stainless steels, and nickel, the rough surface produced no better adherence than the smooth. Gripping action in these cases was not permitted to function properly due to a poorly adherent layer of oxides in contact with the metal. When fired *in vacuo* or in an atmosphere of nitrogen, ground-coat enamel was given an excellent opportunity to adhere by gripping the iron surface directly without the interference of an oxide layer, yet the adherence in these cases was extremely poor.

In many cases of preoxidized metal, adherence on the rough surface was noticeably better than the smooth. This can be explained, however, by the fact that a rough surface may have double or triple the surface area of a smooth surface, thus aiding greatly in oxidation and in retention of thicker coatings of slip.

Only in the case of gold or platinum (and possibly silver) can gripping be said to be active in producing adherence, and the metal in these cases can easily be stripped from the glass layer. The evidence from the above experiments tends to show that gripping is important only in cases where oxidation of the metal surface does not occur.

The *electrolytic theory* maintains that metals higher in the electrochemical series of the elements can displace metals lower in this series from their solution in glass as they do in aqueous solutions. This displacement is accompanied by the precipitation of the displaced metal onto the metallic surface as plates or as dendrites in the enamel layer, which thus cause adherence by "spiking" the enamel to the metal surface.

The experiments reported above have been listed in order of their place in the electrochemical series of the elements from chromium and iron above cobalt to nickel, copper, and the noble metals below. If such a series exists in glass solutions, it is possible that the sequence may be radically different from the series found to hold true for aqueous solutions. In the absence of any known data for a glass series, the known aqueous solution series was used.

If the electrolytic theory is valid, and cobalt is the metal to be displaced from the glass, then chromium, ferro-chrome, the stainless steels, and iron should enamel successfully, and nickel, copper, and the noble metals should not enamel properly with a cobalt ground coat.

The facts are as follows: chromium can not be enameled with a commercial ground-coat enamel unless preoxidized, ferro-chrome has weak adherence unless preoxidized, and straight chromium stainless steel has very poor adherence and is only slightly improved by preoxidizing. The addition of 8% nickel (a metal which is below cobalt in the electrochemical series and can not be enameled) to a chromium stainless steel produces an alloy which enamels fair but which is improved by preoxidizing.

Iron appears to fit into this theory very nicely under customary enameling procedure. When ground-coat enamels on iron are fired, *in vacuo* or in nitrogen, electrolytic action is given its best opportunity to function properly, as the glass layer, unhindered by any iron-oxide layer, is directly in contact with metallic iron and displacement should occur easily. If displacement occurs under these conditions, it certainly is not beneficial to enamel adherence.

Nickel bears out the contention of this theory in that it is below cobalt in the electrochemical series and it does not enamel successfully. Preoxidized nickel, however, enamels fairly well.

Copper, farther down in the series than nickel, should not enamel at all, yet copper can be enameled very well by commercial ground-coat enamels.

The noble metals, still farther down in the series than copper, should have no displacing action at all, yet silver has a remarkable adherence for commercial ground-coat enamels. Fired enamels show a tenacious grip to gold and platinum.

The evidence presented by these experiments tends to show that neither gripping nor electrolytic action is active in promoting adherence of vitreous enamels to metals. Oxide films formed under the enamel layer in all cases except the noble metals, preventing direct contact between glass and metal. In many cases, especially chromium, stainless steel, nickel, and copper, these oxide layers appeared to dissolve with difficulty in the molten glass. These oxide layers, however, stress the importance of an understanding of oxidation in the processes of enameling. Since the

enameling of iron is of primary importance, it is timely here to consider what happens when iron is oxidized.

IV. The Oxidation of Iron

The mechanism of scale formation on iron may best be understood from a study of a series of investigations by Pfeil,[7] Castro and Portevin,[8] and Mathewson, Spire, and Milligan.[9] The equilibrium diagram of the iron-oxygen system from 78 to 70% iron (22 to 30% oxygen), according to Pfeil,[7b] is shown in Fig. 1. The hypothetical compound, FeO, containing 77.74% Fe, does not in reality exist as such, but there is a continuous solid solution of oxygen and iron between the limits of 75% Fe and 76.9% Fe which the author conveniently calls the ferrous phase. The line, *IL*, represents the limit of solubility of metallic iron in the ferrous phase, while the line, *HL*, represents the solubility of magnetite (Fe_3O_4) in the ferrous phase. Below the line, *LM*, at 575°C (1067°F), the ferrous phase is unstable and decomposes into a eutectoid of metallic iron and magnetite. This change is not rapid, however, as it involves heating at 550°C *in vacuo* for long periods for completion. Above 575°C, the ferrous phase is thus seen to exist in three separate fields, associated with magnetite to the right of *HL*, without association in the area between *HL* and *IL*, and associated with metallic iron to the left of *IL*.

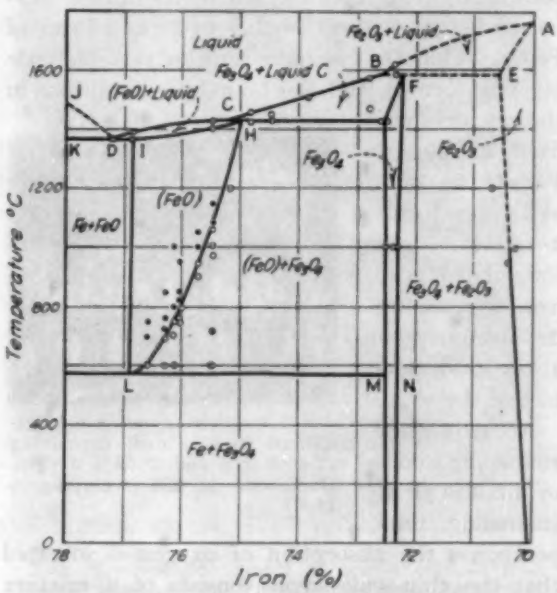

FIG. 1.—Equilibrium diagram of the iron-oxygen system from 22 to 30% oxygen (78 to 70% iron) (according to Pfeil).

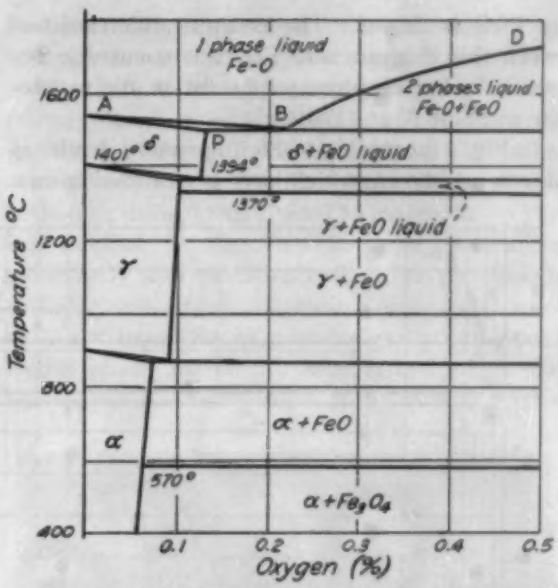

FIG. 2.—Equilibrium diagram of the iron-oxygen system from 0 to 0.5% oxygen (according to Castro and Portevin).

Figure 2 shows the equilibrium diagram of the iron-oxygen system from 0 to 0.5% oxygen (100 to 99.5% Fe) according to Castro and Portevin.[8] Oxygen dissolves in α-iron without change up to 0.06% oxygen at 400°C and increases to 0.075% oxygen at 900°C. Above 900°C α-iron changes to γ-iron with an increase in the solubility of oxygen which ranges close to 0.1% oxygen. Below 570°C magnetite and above 570°C and below 1370°C ferrous phase (FeO) form when the oxygen concentration exceeds its saturation value in α- or γ-iron.

The complete equilibrium diagram of the iron-oxygen system from 0 to 30% oxygen is shown in Fig. 3, according to Mathewson, Spire, and Milligan.[9] These authors show the existence of β-iron between 770° and 900°C but otherwise are in close agreement with work of Castro and Portevin. The hypothetical compound, FeO, does not exist, but a solid solution between the limits given

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[7] (*a*) L. B. Pfeil, "Oxidation of Iron and Steel at High Temperatures," *Jour. Iron Steel Inst.*, **119** [1] 501–47 (1929).
(*b*) L. B. Pfeil, "Constitution of Scale," *ibid.*, **123** [1] 237–58 (1931).

[8] R. Castro and A. Portevin, "Actual State of the Methods for Determining the Oxygen and the Oxides in Iron and Steel," *Rev. mét.*, **29** [8] 418 (1932).

[9] C. H. Mathewson, E. Spire, and W. E. Milligan, "Evolution of the Iron-Oxygen Constitutional Diagram," *Trans. Amer. Soc. Steel Treating*, **19** [11] 66–68 (1931).

by Pfeil is shown. The greatest difference between this diagram and Fig. 1 is a eutectic between the ferrous-phase solid solution and magnetite at point *N* at 1170°C.

In Fig. 4 (according to Pfeil), primary dendrites of iron are shown, which have crystallized from a melt containing 77.46% Fe. This melt contained less iron than the hypothetical compound FeO (77.74% Fe), yet primary iron dendrites have crystallized from it upon cooling.

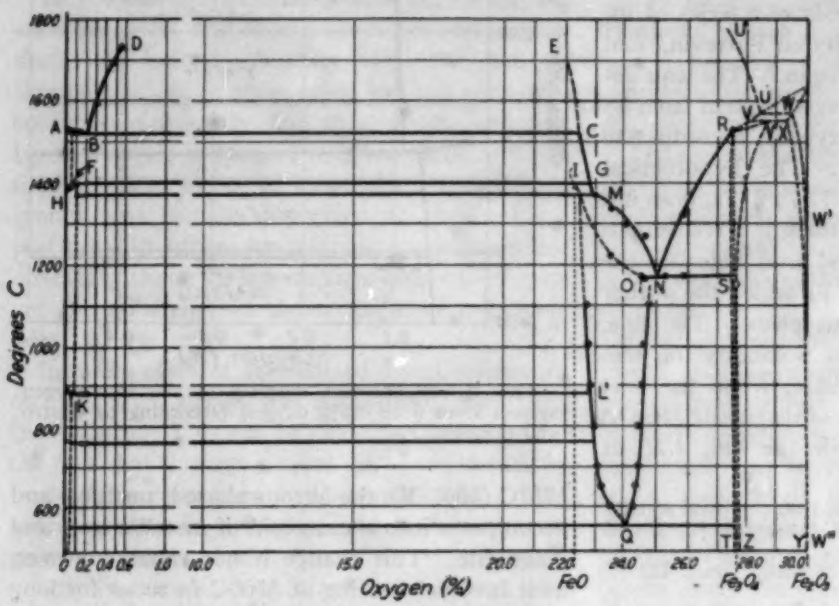

FIG. 3.—Equilibrium diagram of the iron-oxygen system from 0 to 30% oxygen (according to Mathewson, Spire, and Milligan).

Figure 5 shows primary iron dendrites which have crystallized from molten iron oxide in the drip from a ladle. This oxide was entirely ferrous phase and undoubtedly had an iron content greater than 77.23% (point *D*, Fig. 1) or primary iron dendrites could not have formed.

It is interesting at this time to follow the reactions which take place when bright clean enameling iron is placed in an ordinary furnace at enameling temperatures, about 870°C (1598°F). Referring to Fig. 2, the first small amount of oxygen (up to about 0.06%) dissolves in the surface of the iron without apparent change until its saturation value is reached. With additional absorption of heat and oxygen, crystals of magnetite begin to form, and the composition of the outer scale passes through the field of α-iron plus Fe_3O_4 so that the scale is of double construction, consisting of α-iron particles and magnetite. At 570°C, magnetite and α-iron become incompatible and react thus,

$$Fe_3O_4 + Fe \longrightarrow 4(FeO).$$

The scale above 570°C consists of a mixture of α-iron grains and ferrous phase and continues to grow by absorption of iron from the base at its inside surface and oxygen at its outside surface until its oxygen concentration reaches approximately 23% (Figs. 1 and 3). At this concentration of oxygen in the outer scale, α-iron (or β-iron) is no longer stable in the system and the scale forms entirely of ferrous phase. As this ferrous-phase layer grows thicker, oxygen diffuses in more slowly from the surface in contact with the atmosphere and the oxygen concentration at the surface rises to the saturation value for oxygen in the ferrous phase. A layer of Fe_3O_4 then begins to form, which becomes saturated with oxygen at its outside surface, where it oxidizes further to form a layer of Fe_2O_3. Thus the complete series of possible scale layers is formed, and the boundary conditions in the scale are fixed at 69.9% Fe at the outside, where hematite has formed, to pure iron containing dissolved oxygen at the inside surface of the scale.

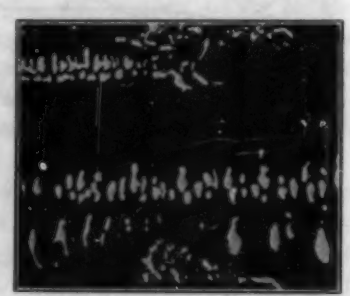

FIG. 4.—Primary dendrites crystallized from a melt containing 77.46% iron and 22.54% oxygen. Unetched. × 250 (according to Pfeil).

Actually when enameling iron is oxidized in air at enameling temperatures, the absorption of oxygen is so rapid that the thin-scale layer consists of a mixture of ferrous phase and magnetite or sometimes wholly magnetite. The α-iron phase can not

FIG. 5.—Primary dendrites crystallized from molten oxide in drip from ladle. Unetched. × 100.

be found in any of these layers due to the high oxygen concentration. To produce ferrous phase in thin-scale layers attached to iron, the oxidation must take place slowly. This may be accomplished by having the oxidation take place in an atmosphere of steam (H_2O), carbon dioxide (CO_2), or a mixture of gases with very low oxygen content. Ferrous-phase scale attached to iron may also be produced in air by the slow diffusion of oxygen through thick-scale layers or through molten slag or glass layers.

FIG. 6.—Rounded grains of α-iron crystals from original iron base in ferrous-phase scale attached to enameling iron produced by heating in steam one hour at 1600°F. Minute specks of secondary iron also visible. Unetched. × 100.

Figure 6 shows an unetched section of the ferrous-phase scale attached to enameling iron produced by heating one hour at 1600°F in an atmosphere of steam. The outer surface of the scale (not shown) had altered to magnetite. The iron surface is somewhat irregular, indicating moderately slow oxidation and, unlike the smooth surface, underlying magnetite scale layers attached to iron. Large, rounded grains of residual α-iron phase are clearly seen imbedded in the ferrous phase. In addition, many minute specks

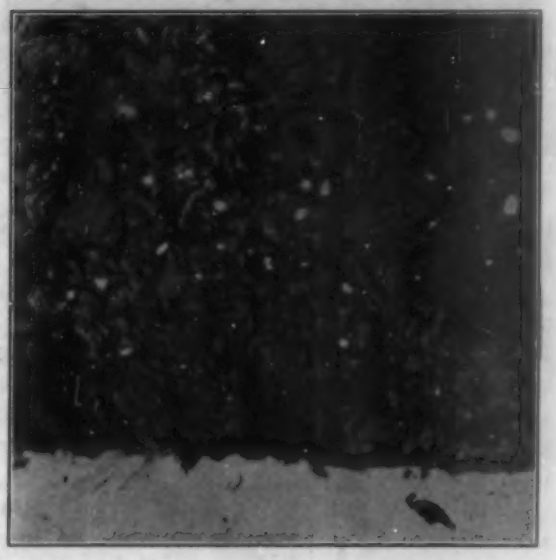

FIG. 7.—Same view as shown in Fig. 6 after etching with alcoholic stannous chloride. Decomposition of ferrous phase into magnetite and secondary iron. Large rounded particles of original iron crystals from base. × 1000.

and thin films of secondary iron, due to decomposition of the ferrous phase upon cooling, are seen.

Figure 7 is the same section shown in Fig. 6 after etching lightly with alcoholic stannous chloride. The decomposition of the ferrous phase upon cooling below 575°C takes place according to the reaction,

$$4(FeO) \longrightarrow Fe_3O_4 + Fe.$$

This eutectoid of magnetite crystals and secondary α-iron can plainly be seen in this etched section. The minute specks of secondary iron are always associated with the skeleton magnetite crystals and appear near their outer surfaces or edges. True primary dendrites of iron can not

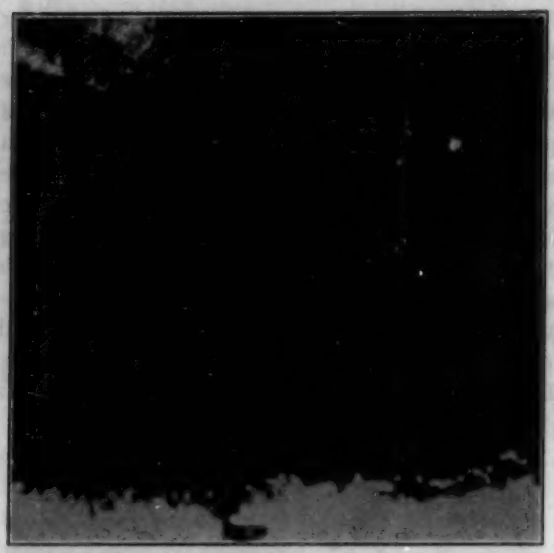

FIG. 8.—Normally fired cobalt ground-coat enamel attached to iron. Unetched. × 1000.

be found and would form only upon cooling this ferrous-phase scale from a molten state.

The oxidation of iron really is a combustion process in which a large amount of heat is evolved. It is possible that, in the oxidation of enameling iron at temperatures near 1300°C, extremely high surface temperatures may sometimes be reached so that the scale fuses and primary iron dendrites form upon cooling.

Metallic iron particles or grains may thus be associated with the ferrous-phase scale in three ways, (*a*) by crystallizing from a melt richer in iron than point *D* of Fig. 1 (77.23% Fe), in which case they would be true primary dendrites; (*b*) by oxidation of the iron surface below 1370°C and above 575°C, in which case they would be residual α-iron phase; and (*c*) by the decomposition of the ferrous phase when cooled below 575°C, in which case they would be secondary α-iron.

V. Microscopic Examination of Enamels Fired on Iron

Many photomicrographs of enamel adhering to iron have been published in the literature. These, in practically all cases, have been photomicrographs of highly polished sections. No attempts heretofore have been made to study these fired enamel layers by using various etching reagents to bring out certain desirable features.

A solution of stannous chloride in ethyl alcohol dissolves iron oxides, especially the ferrous phase, but has practically no action on glass or metallic iron. It also penetrates cracks in the glass and makes them readily visible for microscopic study.

Figure 8 shows a typical micrograph of normally fired cobalt ground-coat enamel on iron. Numerous illustrations almost identical with this have appeared in the literature. This shows a large area of glass (dark) in contact with iron (light), a very irregular iron surface, and numerous irregular metallic particles near the surface. Beyond these observations nothing can be learned from such a photomicrograph.

To illustrate the effect produced by alcoholic stannous chloride upon the enamel layers, the identical section in Fig. 8 is shown after etching in Fig. 9. Two distinct layers of dissolved ferrous phase are seen. The outer layer, consisting of a clear solution of ferrous phase, has many cracks in it extending from the inner layer to the pure enamel glass. The inner dissolved layer has been oversaturated with ferrous phase and contains many particles of the ferrous phase suspended in the glass. The large variously colored areas denote fractured glass behind which the stannous chloride has penetrated. The most remarkable effect of the etchant is shown at the iron surface. Not visible before, the iron surface now clearly shows a thin film of ferrous phase ad-

FIG. 9.—Same as Fig. 8 after etching with alcoholic stannous chloride. Film of ferrous phase attached to iron surface and detached iron particles plainly visible. An inner saturated dissolved layer and an outer dissolved layer containing cracks and fractures also shown. × 1000.

FIG. 10.—Normally fired cobalt ground-coat enamel on iron. Crack formation in outer dissolved layer but not penetrating inner dissolved layer or pure enamel. Deeply etched with alcoholic stannous chloride. × 1000.

hering to the iron. The irregular metallic particles show the same envelope of ferrous phase as does the iron surface. This film of ferrous phase has been calculated to be approximately 3 × 10^{-5} inch thick in this specimen of normally fired ground-coat enamel. The irregular iron surface is characteristic of slow oxidation and indicates that the diffusion of oxygen through the molten glass is very slow at this stage of firing and that oxidation of the iron also proceeds slowly, having time to select the most easily oxidizable portions. The irregular metallic particles near the iron surface, therefore, are not true dendrites at all but detached grains or particles of the iron base undercut from the surface by preferred oxidation along grain boundaries and other planes of weakness. These particles undergo oxidation in the same manner as the iron surface and with continued firing are completely oxidized and absorbed by the enamel glass, while new ones are undercut from the iron surface.

Figure 10, unfortunately overetched with alcoholic stannous chloride, is shown to illustrate the cracks which develop in normally fired cobalt ground-coat enamel upon cooling. The difference in contraction between glass containing suspended ferrous phase and glass containing a clear solution of the ferrous phase produces strains which later develop into cracks. These cracks do not extend into the pure enamel glass or to the surface but only in the outer dissolved layer.

Figure 11 shows unetched cobalt ground coat fired on iron in a commercial plant. This appeared to be normally fired. Quite a layer of scale, formed prior to fusion of the ground coat, is seen with many small spherical particles of iron in it and immediately above. On both extremities of this scale layer are seen large irregular particles of iron. This sample undoubtedly was slightly underfired because (1) the initial scale was not completely dissolved and (2) the irregular surface characteristic of oxidation by slow diffusion had just started to develop. Two kinds of iron particles are illustrated: the irregular detached particles, formed by preferred oxidation of the iron surface, and the small rounded particles of residual iron grains originally formed in the initial-scale layer. The rounded particles of original iron grains have become easily visible at the outer-scale surface by selective solution of the ferrous phase in the enamel glass but can also be seen imbedded in the initial scale. That these particles are original iron and are not formed secondarily by decomposition of the scale upon cooling is conclusively shown by their presence in the glass, at the scale-glass interface, and in the scale. Neither can they be primary iron dendrites formed in the initial scale because the scale was never in a molten condition.

Figure 12 shows unetched underfired cobalt ground coat. The smooth iron surface is characteristic of rapid oxidation and shows undissolved initial scale attached. Immediately above the

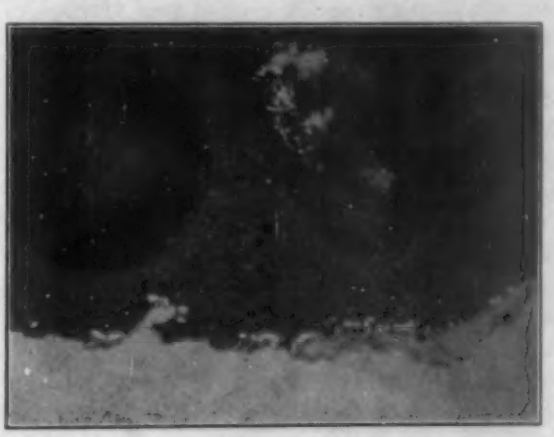

FIG. 11.—Cobalt ground-coat enamel believed to be normally fired on iron. Undissolved initial scale containing particles of residual iron phase within and on outer surface. Detached surface iron particles at extreme left. Unetched. × 1000.

scale layer are seen numerous rounded particles of initial-scale iron phase which have become visible by solution of the ferrous phase in which they were imbedded.

Figure 13 shows another view of the same underfired cobalt ground-coat enamel after etching with alcoholic stannous chloride. Crack formations in the glass are clearly illustrated. The dissolved ferrous-phase layer appears to be banded or stratified. This is probably due to increasing ferrous-phase content in each layer as the iron base is approached. The initial-scale layer now clearly shows its double construction nature of ferrous phase and iron particles. Two kinds of iron particles are present, residual α-iron phase, formed with the scale, and secondary iron, formed by decomposition of the scale. The dark, hazy areas show where excessive solution of the ferrous phase by the etchant has taken place. The iron surface also shows the characteristic smoothness of rapid oxidation.

Figure 14 shows well-fired, commercial white ground coat on iron after etching with alcoholic stannous chloride. The enamel contained no cobalt or other so-called adhering oxides. This glass is such a poor solvent for the initial ferrous-phase scale that only a small amount has been dissolved even though the enamel appears well matured. The extent of the dissolved layer may readily be seen and consists of a clear solution of ferrous phase with practically no suspended material. Many particles of initial-scale iron phase can be seen both above and below the dissolved layer. The double nature of the initial scale is again well illustrated and both the rounded particles of initial-scale iron phase and the thin layers of secondary iron are visible.

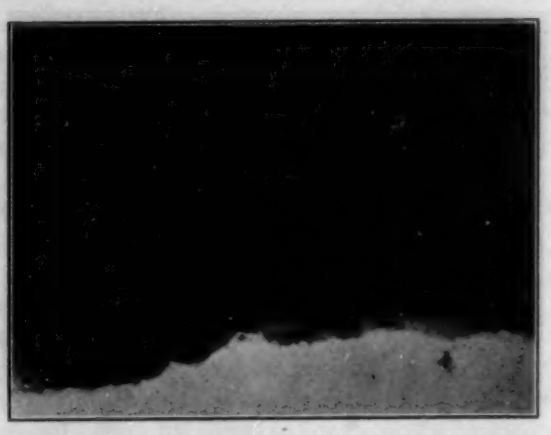

FIG. 12.—Underfired cobalt ground-coat enamel on iron. Relatively smooth iron surface with undissolved initial scale attached. Rounded grains of residual α-iron phase in and above outer surface of initial scale. Unetched. × 1000.

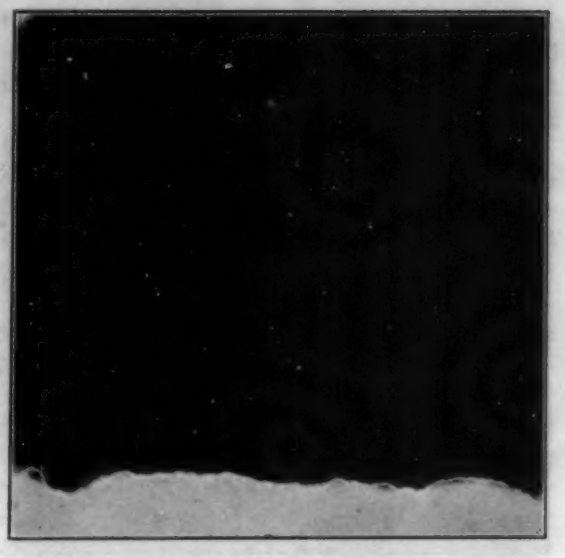

FIG. 13.—Underfired cobalt ground-coat enamel on iron. Crack formation in glass. Banded dissolved ferrous-phase layer. Double nature of initial-scale layer consisting of ferrous phase and iron particles, both residual and secondary. Etched with alcoholic stannous chloride. × 1000.

Figure 15 also shows well-fired, white ground coat on iron which has been etched with alcoholic stannous chloride and then lightly repolished. The dissolved layer extends much higher in this specimen and contains many large particles of initial-scale iron phase. The initial scale has not completely dissolved and shows many particles of residual iron phase and secondary iron. It is remarkable that initial-scale iron phase is found so far from the scale surface in this type of glass and well illustrates the poor diffusion of oxygen in the metallic oxide-free glass which allows the iron particles to remain unoxidized and suspended at high levels.

Figure 16 is a photomicrograph of commercial cobalt ground-coat enamel, fired on iron for ten minutes at 1600°F in an atmosphere of purified nitrogen. This has been etched with alcoholic stannous chloride. No dissolved layer can be seen in the glass nor can initial-scale iron phase or detached surface iron be found. The iron base presents a fairly smooth surface, being roughened only slightly by nitriding action. The adherence of the glass to the iron was extremely poor, yet advantageous conditions existed here for gripping,

electrolytic, or dendritic action to function in producing adherence.

Figure 17 shows commercial cobalt ground-coat enamel, well fired on enameling iron scale after etching with alcoholic stannous chloride. This surface of the scale had altered completely to magnetite shown by the long columnar crystals. Practically no solution of the magnetite has taken place as only a very slight banding is visible. Cracks extend throughout the glass and tend further to indicate the absence of a dissolved oxide layer.

Figure 18 shows the opposite surface of the same etched specimen in Fig. 17. The alteration to magnetite was not complete at this surface, and the scale consisted of a mixture of magnetite and decomposed ferrous phase. Selective solution of the ferrous phase by the glass has taken place, and a decided dissolved layer can be seen. These photomicrographs emphasize the very soluble nature of the ferrous phase and the insoluble nature of magnetite in molten enamel glass.

Figure 19 shows overfired commercial cobalt ground-coat enamel after etching with alcoholic stannous chloride. The enamel at this stage is green colored and shows numerous spangles or fractures. Microscopic study shows that the dissolved ferrous-phase layer extends almost to the outer surface of the glass and that it is now the field where extensive crack formation takes place. That the rate of diffusion of oxygen has been increased is shown by the smoother iron surface and a decreased amount of detached iron particles.

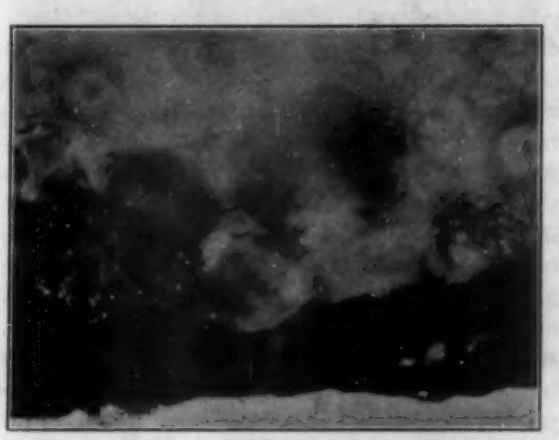

FIG. 14.—Well-fired white ground coat on iron. Poor solubility of ferrous phase in glass. Initial-scale iron phase and secondary iron in initial-scale layer. No diffused oxygen attack on iron surface. Etched with alcoholic stannous chloride. × 1000.

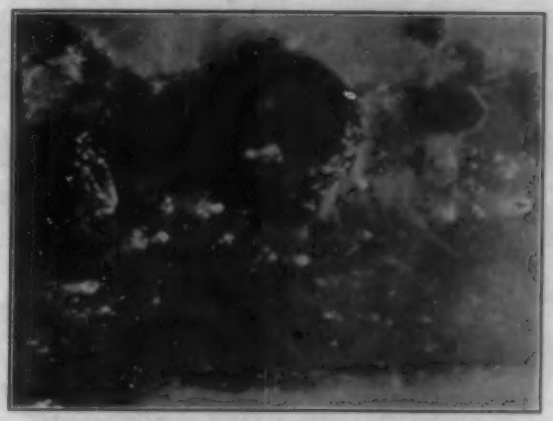

FIG. 15.—Well-fired white ground coat on iron. Residual iron phase in undissolved initial scale and also far from iron surface in dissolved ferrous-phase layer of glass. Etched with alcoholic stannous chloride. × 1000.

The concentration of oxygen in the outer dissolved ferrous-phase layer sometimes rises beyond its saturation value and magnetite crystals are formed. In cooling, the difference in the rate of thermal contraction between the glass after becoming rigid and the magnetite crystal is so great that strains occur which often cause fractures commonly known as shiner-scale. The photomicrograph clearly shows a large magnetite crystal and the resulting shiner-scale fracture. The area surrounding the crystal appears to be deficient in ferrous phase and is probably due to the glass being robbed of this constituent in order to feed, or contribute to the growth of, the less soluble magnetite crystal.

When ground-coat enameled iron is fired for excessively long periods it becomes dull, opaque, and of a brown-red or copper color. This is commonly referred to as "burned-off" enamel. Figure 20 is an unetched photomicrograph of commercial cobalt ground-coat enamel on iron fired to the "burned-off" stage. The iron surface is less irregular than in normally fired enamels and shows very little undercutting and detached surface iron, indicative of an increased rate of oxidation by diffusion. In contact with the iron surface are seen numerous prismatic crystals of ferrous phase. These show slight decomposition into secondary iron and magnetite near the iron surface but, at their outer limit, the oxygen concentration has reached its saturation value and the ferrous phase has altered to magnetite. Immediately above the ferrous-phase crystals, many octahedral crystals of magnetite are seen in the

glass. Near the outer surface of the glass, the magnetite crystals are seen to be altering to long, needle-shaped or rod-shaped crystals of hematite.

A petrographic examination of enamel at this stage of firing by the fine powder-oil immersion method revealed six different substances to be present.

Isotropic, nearly colorless; index near 1.52; identified as pure enamel glass.

Isotropic; brown or amber color; index variable; above and below 1.74; identified as enamel glass rich in ferric oxide.

Opaque; dark gray color; aggregates; index indeterminable; believed to be ferrous-phase crystal aggregates.

Opaque; black; compact masses; index indeterminable; believed to be magnetite.

Anisotropic; amber color, strong birefringence; indices close to acmite ($Na_2O \cdot Fe_2O_3 \cdot 4SiO_2$).

Anisotropic; blood-red color; acicular; parallel extinction; indices greatly in excess of 1.80; identified as hematite.

Thus it is seen that the same reactions which take place in the formation of scale on iron at high temperatures take place through the molten enamel layer on iron and the same products are formed. "Burned-off" enamel then is simply enamel glass in which all possible iron scale layers have formed from the iron base by diffusion of oxygen through the molten glass layer.

VI. The Diffusion of Oxygen in Molten Enamels

It is commonly believed that oxidation of the iron surface under ground-coat enamels ceases with fusion of the glass. This is not the fact as the excessively fired enamel saturated with iron oxides so ably demonstrates. The rate of oxygen diffusion is suddenly retarded when fusion takes place but does not cease. After fusion of commercial cobalt ground-coat enamels on iron, solution of the initial scale takes place predominately, in spite of a slow diffusion of oxygen, through the pure molten enamel glass. At the normal stage, diffusion has been accelerated slightly by solution of the initial scale and preferred oxidation of the iron base occurs, producing irregular detached surface iron particles and a very irregular surface. As the iron-oxide content of the enamel increases, the rate of oxygen diffusion increases, shown by the smoother or less irregular iron surface in excessively fired enameled iron. Thus ferrous oxides in the enamel promote diffusion of oxygen, and it is probably true that other metallic oxides, such as manganese, copper, cobalt, and nickel, act in a similar manner. White ground coats containing no so-called adhering oxides are such poor mediums for oxygen diffusion that unoxidized particles of initial-scale iron phase are found in the glass at considerable distances from the iron surface.

FIG. 16.—Commercial cobalt ground-coat enamel fired on iron in atmosphere of nitrogen. No dissolved layers in glass. No iron or other metallic particles in glass or at iron surface. Very slight nitriding action at iron surface. Etched with alcoholic stannous chloride. × 1000.

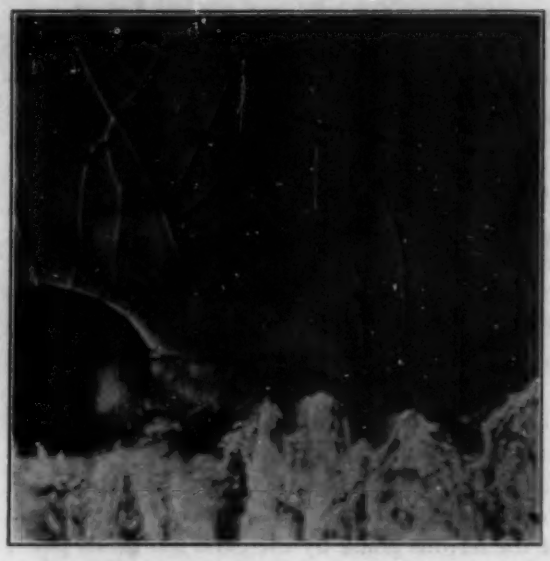

FIG. 17.—Well-fired cobalt ground-coat enamel on enameling iron scale. Columnar crystals of magnetite in contact with glass. Well-developed crack formation throughout glass. Low solubility of magnetite in enamel glass shown by lack of extensive dissolved layers. Etched with alcoholic stannous chloride. × 1000.

VII. Dendrites in Ground-Coat Enamels Fired on Iron

Microscopic examination of numerous polished sections of underfired, normally fired, and overfired ground-coat enamels failed to reveal anything that in the strictest sense of the word could be called true metallic dendrites. In underfired enamels, rounded grains of residual initial-scale iron phase are usually found near the outer surface of the initial scale where solution in the enamel has taken place. In the initial scale underlying the underfired enamel layer, residual grains of initial-scale iron phase and secondary iron are generally present. In normally fired and overfired enamels, detached surface iron only is found. When the normal stage is reached, all initial-scale iron phase has been completely oxidized and absorbed by the enamel glass.

Any metallic particle, whether iron or other metal, in order to form primarily in the glass would have to form under oxidizing conditions and would have to be unoxidizable to remain as such in normally fired ground coat. In other words, oxidizable metallic particles are not stable in this system of ever-increasing oxygen concentration.

All metallic particles observed were iron and obviously must be such because they are present in white ground-coat enamels as well as in cobalt ground coats. Cobalt oxides or other so-called adhering oxides in the glass are not necessary for residual particles of initial-scale iron phase to be present in underfired enamels. Iron particles, whether initial-scale iron phase or detached surface iron, must necessarily be α-iron because they are both remnants of the original grains of the enameling iron base which itself is almost pure α-iron. According to some investigators, α-iron is the stable allotropic form of iron below 1652°F and thus the form which is present throughout enameling operations. Secondary iron formed upon cooling ferrous-phase scale would also be α-iron.

FIG. 18.—Opposite surface of same enameled scale shown in Fig. 17 consisting of a mixture of magnetite and decomposed ferrous phase. Dissolved layer in glass formed by selective solution of easily soluble ferrous phase with concentration of difficultly soluble magnetite crystals at contact surface. Etched with alcoholic stannous chloride. × 1000.

FIG. 19.—Cross-section of shiner-scale fracture in excessively fired cobalt ground-coat enamel on iron. Fracture caused by difference in thermal contraction between solidified glass and magnetite crystal upon cooling. Smoother iron surface indicates more rapid oxidation. Ferrous-phase film adhering to iron. Etched with alcoholic stannous chloride. × 1000.

True primary dendrites or crystals of iron possibly could form in oversaturated enamels on iron fired above point *D* of Fig. 1, or 1370°C (2500°F), but not in unsaturated enamels normally fired.

The detached surface iron particles found in normally fired ground-coat enamels are not fixed but are continually undergoing oxidation and absorption in the enamel. Their presence near the iron surface presents a plane of weakness which undoubtedly is not beneficial to enamel adherence.

VIII. The Role of Cobalt in Ground-Coat Enamels

The literature is sadly lacking in data of the solubility of the three iron oxides in cobalt glasses. Some partial determinations of the solubilities of hematite (Fe_2O_3) and magnetite (Fe_3O_4) (the most insoluble oxide) have been made in enamel glasses, but no work of any description has been recorded of the solubility of ferrous phase (the most important compound in enameling) in enamel

glasses of different cobalt content. Spencer-Strong and King[18] studied the phases present in a series of enamel glass melts of decreasing hematite content and increasing cobalt oxide content.

The author[10] has produced beautiful black glazes at cone 6 with only ferric oxide and cobalt oxide as the colorants. Hematite, or ferric oxide, had a low solubility in these glazes, ranging between 1% and 2% depending upon composition. The brownish-red opaque glazes were assumed to be oversaturated and to contain undissolved or suspended ferric oxide. Cobalt oxide produced clear, transparent blue glazes up to 10%, the limit of the study, and when used with equal parts of ferric oxide produced clear, glossy, black glazes, showing no suspended material in thin sections up to 6% of each constituent. These studies ably showed the greatly increased solubility of ferric oxide in glazes containing cobalt oxide. The increased solubility in these cases may be due to the formation of cobalt ferrite ($CoO \cdot Fe_2O_3$).

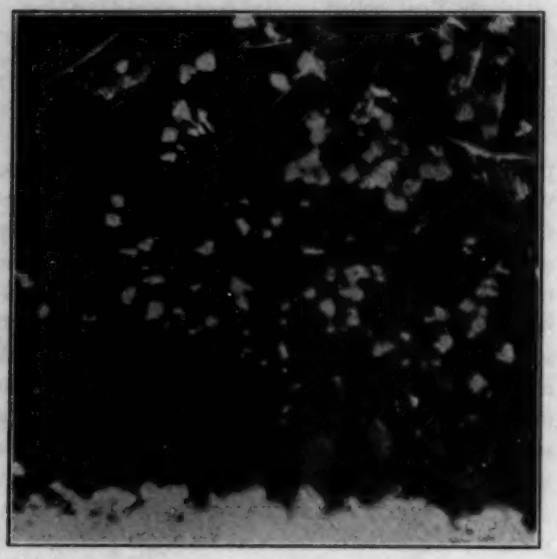

FIG. 20.—Enamel glass on iron fired to "burned-off" stage. Saturation of glass with all possible iron oxides. Acicular crystals of hematite at outer surface, octahedral crystals of magnetite in center, and prismatic crystals of ferrous phase near iron surface. Less prominent undercutting and smoother iron surface indicates more rapid oxidation. Unetched. × 1000.

From the microscopic study made, it was shown that the ferrous phase has extremely poor solubility in white ground coats even though apparently well fired. In commercial ground-coat enamels containing cobalt, nickel, and manganese compounds, the ferrous phase dissolves easily and rapidly.

Vielhaber[5] believes that the purpose of cobalt oxide in ground-coat enamels is to partially saturate the glass to reduce its iron-oxide dissolving power and thus to prevent complete solution of the initial scale. It has been found, however, that if the initial scale is not completely dissolved, poor adherence results often accompanied by fish-scaling.

From the data so far obtained, it appears that the special rôle of cobalt in ground-coat enamels is primarily to increase the solution of ferrous phase in the glass and secondarily to function as an oxygen carrier through the molten glass.

IX. Stages of Oxidation in the Firing of Ground Coats

The complete firing of commercial cobalt ground-coat enamels on iron falls naturally, according to the degree of oxidation, into six periods or stages.

(1) Scale-Formation Stage

This period extends from the time the iron, coated with dried enamel glass slip, enters the furnace up to the time the glass particles are fused together. Oxidation of the iron surface starts below 700°F and increases rapidly as the temperature increases. The layer of closely packed glass fragments and clay acts in a manner similar to a thick-scale layer in preventing extremely rapid oxidation of the iron surface. The composition of the initial-scale layer formed on the iron surface may thus vary greatly according to the thickness of the dried coating and its porosity, the rate of heating during its formation, and the composition of the furnace atmosphere and its rate of flow past the absorbing surfaces. The scale may be (*a*) entirely a mixture of ferrous phase and magnetite, (*b*) entirely ferrous phase, or (*c*) entirely ferrous phase containing rounded particles of residual α-iron phase. Sometimes all three layers are present, the scale ranging from (FeO) + Fe_3O_4 at the outside, through (FeO) to (FeO) + α-Fe in contact with the iron base. This stage ends at a temperature near 1400°F or when the glass particles have just fused together.

[10] K. Kautz, "Enamels of Standard Color for Vitreous China Sanitary Ware at Cone 6," *Jour. Amer. Ceram. Soc.*, 16 [4] 192–98 (1933).

(2) Scale-Solution Stage

The temperature continues to increase and approaches the furnace temperature as a limit. Solution of the initial ferrous-phase scale by the molten glass takes place and is the predominating process. Oxygen diffusion to the metal surface has suddenly been greatly retarded by the glass becoming fluid but increases slowly again as the molten glass becomes richer in ferrous phase. Residual particles of iron phase present in the inital scale are temporarily suspended in the glass by solution of the surrounding ferrous phase and must undergo oxidation by diffusing oxygen through the molten glass before complete solution occurs. If the scale contains magnetite, a longer period is required for its solution due to its difficultly soluble nature in enamel glass. Some types of cobalt ground-coat enamels appear to dissolve magnetite more readily than others. If magnetite, however, is not completely dissolved at this stage, it usually causes defects in subsequent operations. After complete solution of the initial ferrous-phase scale and its particles of residual α-iron phase (or crystals of magnetite), diffusing oxygen begins to oxidize the surface of the iron base.

(3) Normal Stage

Diffusion of oxygen through the molten glass has now reached the stage where a very slow oxidation of the iron base takes place. The most easily oxidizable portions of the base are first oxidized, probably along grain boundaries, planes through mechanically distorted crystals, and the least resistant crystal faces. This results in a very irregular iron surface, with much undercutting along preferred paths and many irregular particles of the iron being completely detached from the base. The detached particles as well as the iron surface are continually being oxidized to ferrous phase which is rapidly absorbed by the molten glass. Equilibrium is never attained, so that during this stage, when the piece is withdrawn from the furnace and allowed to cool, there exists a thin film of ferrous phase attached by means of a solution bond to the iron on one side and also by means of a solution bond to the enamel glass on the other side. In other words, a thin film of ferrous phase, approximately 3×10^{-5} inch thick, appears to function as a cement to bind glass and iron together and is believed to be the fundamental cause of the adherence in normally fired ground coats on iron. This may explain why the adherence of base enamels on iron never exceeds a certain value which is fixed by the degree of adherence between ferrous phase and iron.

The dissolved ferrous phase extends less than half way through the enamel at this stage and probably produces a series of glasses intermediate in coefficient of thermal expansion and contraction between pure enamel glass on one side and the iron base on the other. This dissolved ferrous phase appears to consist of two distinct strata. The inner stratum in contact with the iron is apparently saturated and contains many particles of undissolved ferrous phase. The outer stratum seems to be banded and to consist of layers of diminishing ferrous phase content as the pure enamel glass is approached. A characteristic crack formation exists in this outer stratum which does not extend into the pure glass or into the inner stratum.

(4) Ferrous-Phase Saturation Stage

Continued firing after the normal stage is reached results in the continued formation of ferrous phase at the iron surface and its solution by the molten glass. Eventually the dissolved layer reaches almost to the outer surface of the glass. The enamel at this stage exhibits a characteristic gray-green or brown-green color. By continued absorption of oxygen, the saturation value of oxygen in the dissolved ferrous phase (curve *HL* in Fig. 1) is reached and alteration to magnetite begins to take place. Magnetite, being so much less soluble in the enamel glass than the ferrous phase, may grow into crystals of considerable size. If withdrawn and cooled at this stage, the difference between the rate of contraction of glass, which has become rigid, and the magnetite crystals produces severe strains which often cause fractures in the glass known as shiner-scale.

(5) Magnetite-Saturation Stage

Continued firing and absorption of oxygen after the ferrous-phase saturation stage is reached results in the formation of an extensive layer of magnetite crystals immediately beneath the surface of the glass. The enamel at this stage exhibits a characteristic glossy black appearance. This color may possibly be due to initial alteration of magnetite to hematite near the surface with the formation of cobalt ferrite ($CoO \cdot Fe_2O_3$)

and its solution in the glass. This black glass changes to deep amber upon continued heating and is probably glass saturated with ferric oxide. With continued heating, this amber glass becomes opaque and reddish-brown due to crystallization of hematite.

(6) Hematite-Saturation Stage

With continued firing and diffusion of oxygen, the enamel becomes saturated with respect to each possible iron oxide. At the outer surface, where the greatest concentration of oxygen exists, the enamel has become saturated with respect to the highest product of oxidation of iron, and long, needle-shaped crystals of hematite form. This network of hematite crystals makes the enamel appear dull, opaque, and of reddish-brown color. Immediately below this hematite layer, the glass has become saturated with oxygen to the extent where magnetite crystals are the stable form. Near the iron surface, the concentration of oxygen is such that the enamel is saturated with respect to ferrous phase and crystals of the ferrous-phase form. These ferrous-phase crystals are often attached directly to the iron surface. Thus all possible iron oxides have formed from the iron base by diffusion of oxygen through the molten enamel.

Continued firing and diffusion of oxygen, after stage (6) is reached, is properly merely the scaling of iron at high temperatures. The scale grows thicker, and first the ferrous phase and then the magnetite layers are formed below the enamel glass, which thus becomes a matrix for the hematite crystal layer.

X. Summary and Conclusions

No evidence was found in any of the experiments performed which tends to show simple gripping or mechanical bonding to be a factor in the adherence of ground-coat enamels to oxidizable metals. The weak adherence found on the noble metals may satisfactorily be explained by a simple gripping action.

Electrolytic reactions apparently do not take place on iron *in vacuo* or in nitrogen, the most advantageous conditions for this type of reaction; if they do they are not beneficial to adherence. Poor adherence on chromium, a metal higher in the electrochemical series than iron, and relatively good adherence on copper, a metal below cobalt and nickel in the series, tend further to discredit the action of electrochemical displacement.

Microscopic investigations of iron-enamel contact zones did not reveal the presence of metallic crystals which properly could be called true dendrites. Rounded particles of initial-scale iron phase were found to be present in enamel layers which were underfired, and initial-scale iron phase together with secondary iron in the initial scale underlying underfired enamels. In normally fired enamels, only irregular particles of detached surface iron were found. Both the detached surface iron and the iron surface had a film of ferrous phase adhering to the metal. Oxidizing conditions exist in the glass layer at the normal stage of firing, and any oxidizable metallic particles must undergo oxidation.

Cobalt oxide appears to promote solution of ferrous phase in the enamel glass and to act as an oxygen carrier in the molten glass.

It is concluded, therefore, that neither gripping, electrolytic reactions, nor dendrites are the fundamental causes of commercial cobalt ground-coat enamel adherence to iron but that the enamel glass is rigidly held to the iron through the medium of a film of ferrous phase approximately 3×10^{-5} inch thick.

These experiments and observations are in agreement with the work of Cooke[2a,b] and Dietzel and Meures[6a] and clearly emphasize the important rôle played by oxygen in the firing of base enamels on iron.

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EFFECT OF MILL ADDITIONS ON THE THERMAL EXPANSION OF SHEET-IRON GROUND-COAT ENAMELS*

By R. L. Fellows and E. E. Howe

Abstract

Since the effect on thermal expansion of clay, feldspar, and silica, when introduced as mill additions to a sheet-iron ground-coat enamel, has not hitherto been clearly shown, thermal-expansion studies were made on a two-frit ground-coat enamel for sheet iron, varying the amounts of clay, feldspar, and silica within reasonable limits of mill additions.

It is common practice to use a combination of a hard and a soft frit ground coat to give greater flexibility in firing and operation, but it is not known whether the two frits form a single glass upon firing to give an expansion dependent upon the relative amounts of each frit present. Thermal-expansion tests, therefore, were also made on enamels containing varying proportions of high- and low-expansion frits.

Results were obtained by the use of the interferometer, and the rod method of making specimens as used by Andrews and Smith[1] was compared to the plate method described in this paper. Through the use of these two methods of preparing the samples, a comparison of the relative solubility of the mill additions in the ground-coat frit was secured.

I. Experimental

A hard frit, No. 1, of low expansion and a softer one, No. 2, of high expansion, which are used in combination in commercial practice, were selected for this study. The frits which had originally been dried were screened through a coarse sieve ($^1/_8$-inch openings) to insure complete grinding in the small experimental mills.

Frit batches of 25 ounces were weighed out accurately and placed in porcelain-lined mill jars along with the various mill additions shown in Table I. The enamels were allowed to grind until a fineness of 12 to 14% was obtained when tested by the American Ceramic Society method[2] of determining fineness on wet-milled enamels. The milled enamels were then screened through a 40-mesh sieve, placed in flat pans, and allowed to dry. When thoroughly dry, they were transferred from the pans to a porcelain mortar and the lumps were broken up.

(1) The Plate Method

In the plate method, about 40 grams of each sample were placed in a conical pile on an untreated square piece of enameling iron (3 by 3 inches) and then into a small laboratory furnace operating at 1600°F. When the enamel had fused down to a flat plane, requiring about ten minutes, the plate was removed from the furnace, transferred to an annealing furnace at 1400°F, and allowed to cool slowly to room temperature.

As far as it was possible to determine from the subsequent expansion tests, the samples were fully annealed and no strains were set up due to the differential contraction between the enamel and the steel, although the enamel had broken off from the base plate.

After cooling, the samples were broken into small pieces and ground down on a silicon-carbide wheel into conical specimens suitable for mounting in the interferometer. These specimens were so prepared that the long axis of the cone lay in a plane parallel to that of the iron on which it had been fused. This made it possible to use a thinner layer of enamel and thus more closely simulate actual enameling conditions. Three of these samples, which had an approximate height of 0.45 centimeter and a diameter of 0.30 centimeter at the base, were prepared from each enamel in this manner. The exact height of these cones was measured by means of a micrometer caliper which read accurately to 0.0005 centimeter; they were then placed in the interferometer furnace and adjusted until at least 4 and not more than 8 fringes appeared in the field of view.

The furnace, which had previously been calibrated, was started and the temperature raised at the rate of 3.3°C per minute. The temperature was recorded as each fringe passed a reference

* Presented at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., February, 1935 (Enamel Division).

[1] A. I. Andrews and R. K. Smith, "Thermal Expansion of Sheet-Iron Ground-Coat Enamels," *Jour. Amer. Ceram. Soc.*, **16** [7] 328–37 (1933).

[2] Standards Report, "Fineness of Wet-Milled Enamel," *Jour. Amer. Ceram. Soc.*, **11** [6] 466–67 (1928).

TABLE I

Batch Compositions

	1	2	3	4	5	6	7	8	9	10	11	12	13
Frit No. 1	100		60	60	60	60	60	60	60	60	60	40	60
Frit No. 2		100	40	40	40	40	40	40	40	40	40	60	40
Clay*	7	7	7	7	7	7	7	7	7	4	10	7	
Silica†	3	3		3	6	9						3	
Feldspar‡							3	6	9				
Borax	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4
Water	40	40	40	40	40	40	40	40	40	40	40	40	40

*Vallendar clay.
† 200-mesh silica.
‡ 140-mesh potash feldspar.

point and from this data linear thermal-expansion curves were obtained. The softening temperature was taken at the point where the fringes reversed direction.

In all of the expansion tests, the initial observation was taken at 36°C, thus insuring a common starting point on all of the curves. Thermal cubical expansion values in the temperature range of 36 to 336°C were obtained from the linear-expansion curves. Since the cubical expansion is three times the linear, by choosing a point 300° from starting, the cubical expansions can be read directly from the graphs merely by changing the decimal point. This temperature range lies below the lower critical temperature encountered in practically all enamels.

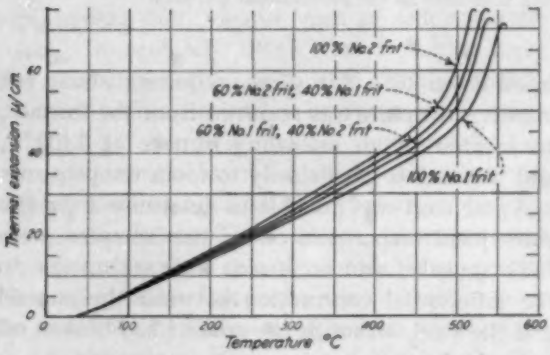

FIG. 1.—Effect of blending two frits upon the linear thermal expansion (rod method of preparing sample).

Mill formula	
Frit No. 1	0–100
Frit No. 2	100–0
Clay	7
Silica	3
Borax	3/4
	110 3/4

The rod method, which has been described in detail in previous papers,[1] was used on each composition studied. In brief, this method consisted in melting the dried milled enamels in a crucible and in drawing rods of enamel from them. After annealing in a small laboratory furnace, cone-shaped specimens for the interferometer were formed from the rods. By this method, the mill additions were given a better chance to dissolve in the frit, since the temperature was higher than that used when the enamel was fired onto the steel.

II. Results

Figure 1 shows the effect on the thermal expansion and softening temperature when two frits are used in conjunction in an enamel. Only the results of the rod method are plotted, since those obtained by the plate method were identical.

In Table II, the results obtained by the use of the rod and the plate methods on the cubical thermal expansions are given. The softening temperatures of the enamels are also given in this table.

The effect on the cubical expansion of increasing the amount of clay in an enamel, as determined by both the rod and the plate methods, is shown in Fig. 2.

The effect on the cubical expansion of increasing the amounts of feldspar and silica in an enamel, as determined by both the rod and the plate methods, is shown in Fig. 3.

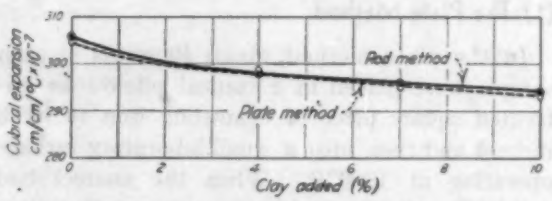

FIG. 2.—Effect of clay upon the cubical thermal expansion of a blended frit ground-coat enamel.

Mill formula	
Frit No. 1	60%
Frit No. 2	40
Clay	0–10
Borax	3/4

TABLE II

CUBICAL EXPANSIONS × 10^{-7} AND SOFTENING TEMPERATURES IN °C OF ENAMEL COMPOSITIONS

Batch No.	Plate method: Cubical expansion (°C × 10^{-7}) (36–336°C)	Plate method: Softening temp. (°C)	Rod method: Cubical expansion (°C × 10^{-7}) (36–336°C)	Rod method: Softening temp. (°C)
1	273	552	270	554
2	320	518	314	518
3	295	533	296	533
4	290	535	285	540
5	292	547	283	545
6	292	541	281	563
7	290	533	293	540
8	291	535	294	537
9	294	550	291	543
10	299	533	298	538
11	293	539	293	540
12	298	529	298	536
13	305	535	306	538

III. Discussion of Results

Figure 1 shows that the thermal expansion and softening temperature of an enamel is dependent upon the amount of each frit present in a two-frit ground coat. Any desired intermediate expansion between the high- and the low-expansion frits could be obtained by varying the proportion of the frits.

From Fig. 2 it can be seen that clay lowers the thermal expansion of an enamel. An addition of 10% clay resulted in a decrease in the expansion from 306 to 293. Figure 2 also shows that clay is readily soluble in the enamel since the cubical expansion results obtained by the two methods are practically identical. This bears out the work of Noble[3] who found in the X-ray study of mill additions that 7% clay, 3% feldspar, or 3% silica were completely soluble in the enamel during firing.

When the effect of silica upon the thermal expansion is compared to that of feldspar (Fig. 3), it may be seen that the former lowers the expansion to a greater degree. An addition of 9% silica resulted in a decrease in the thermal expansion by the rod method from 296 to 281, while a corresponding amount of feldspar lowered the expansion from 296 to 291.

A comparison of the results obtained by the two methods (Fig. 3) shows that the plate method

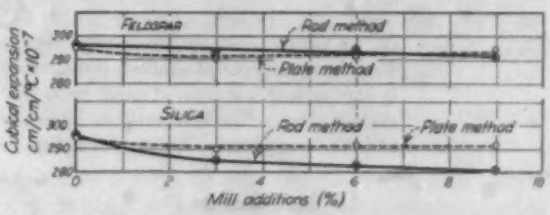

FIG. 3.—Effect of feldspar and silica upon the cubical thermal expansion of a blended frit ground-coat enamel.

Mill formula	
Frit No. 1	60%
Frit No. 2	40
Clay	7
Variable	0–9
Borax	3/4

checks the rod method in the case of feldspar but not silica. This difference noted in silica might be attributed to the comparative insolubility of silica in the enamel used.

IV. Summary

(1) The thermal expansion of an enamel is proportional to the amount of high- and low-expansion frit present in a two-frit ground coat.

(2) The softening temperature of an enamel is dependent upon the relative amounts of hard and soft frit present in a two-frit ground coat.

(3) Clay, silica, or feldspar lower the thermal expansion when introduced as mill additions to the enamels used in this investigation.

(4) Results obtained by the plate method of preparing specimens do not always check those obtained by the rod method, and therefore, might offer a means of comparing solubilities of the materials.

(5) Results indicate that clay and feldspar are more soluble than silica in the ground-coat enamel used.

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[3] W. N. Noble, "X-Ray Study of Action of Mill Additions in Fired Ground-Coat Enamels," *Better Enameling*, **4** [9] 8–10 (1933); *Ceram. Abs.*, **12** [12] 413(1933).

SOME EXPERIMENTS IN THE DEVELOPMENT OF A SAND-ABRASION MACHINE*

By G. H. Spencer-Strong

Abstract

A simple and comparatively inexpensive apparatus for determining the relative abrasion resistance of enamels is described. Abrasion is obtained by fixing the specimen in the path of a stream of sand, propelled by a rapidly revolving disk. The severity of the abrasive action is dependent upon the particle size of the abrasive. Data are given as to the comparative resistance both to severe and mild abrasion of several enamel types.

I. Introduction

One of the important factors affecting the useful life of a porcelain enameled product is its resistance to abrasion. In certain cases, this property may become one of the primary factors in the selection or development of the most suitable enamel for a given product. Abrasion, as encountered in enamels, may be considered from two standpoints, (1) surface abrasion in which the gloss is destroyed, leaving the enamel dull and dirty looking and (2) complete destruction of the enamel covering, exposing the metal to corrosion. The latter abrasion, for want of a better term, may well be called destructive abrasion, since the surface abrasion does not destroy the protective qualities of the covering but merely mars its beauty.

Any apparatus for the measurement of the abrasion resistance of vitreous enamels should be sufficiently flexible to enable the determination of either type of abrasion at will with a minimum of effort.

II. Devices for the Measurement of Abrasion

In the paint and lacquer industries, the importance of abrasion resistance is well recognized, and devices to measure it have been developed to a much greater extent than in the ceramic industries. A recent work[1] on the testing of paint and lacquer products describes, in considerable detail, seven machines for the measurement of abrasion resistance. In the Gardner abrasion test, the test panel is mounted at an angle of 45° below a 6-foot glass tube having an internal bore of $^{7}/_{8}$ inch. Emery powder or 20-mesh Ottawa sand is poured through the tube from a funnel. The volume or weight of sand required to abrade through the coating is measured. In the Bell Laboratory abrasiometer, a Carborundum air-blast, is used to wear away the film under test. The weight of abrasive required to wear through a unit thickness of film measures the abrasion resistance. The Bell Laboratory rotating-disk abrasion test utilizes a coated disk which is rotated in a vessel containing a fine grade of sand. The amount of film lost is the measure of abrasion resistance. In the Parlin abrasion test, an abrasive-tipped tool is fastened to a moving carriage. A counter attached to the carriage measures the number of oscillations required to rub through a lacquer. The severity of the test may be regulated by the type of tip employed and by the weight of the tool.

The Camp and the Wolff methods employ a turntable to which the test piece is fastened under an arm tipped with abrasive which destroys the surface under test.

In the ceramic field, Scott,[2] Harrison,[3] and Schramm[4] have reported abrasion tests on glazes, while Kinzie[5] has described a method for testing enamels. Scott[2] and Harrison[3] used a modification of the Gardner test, the former determining abrasion by measuring the loss in weight of the sample after 64 pounds of sand had fallen upon it; Harrison determined abrasion from the amount of sand necessary to reduce the gloss of the sample, *i.e.*, 10% as measured by the Ingersoll glarimeter.

Schramm[4] used a modified sandblast upon a rotating sample. His method consists of building

* Presented at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., February, 1935 (Enamel Division). Received September 26, 1935.

[1] H. A. Gardner, Physical and Chemical Examination of Paints, Varnishes, Lacquers, and Colors, 6th ed., 1933. Institute of Paint and Varnish Research.

[2] W. J. Scott, "An Apparatus for Measuring the Abrasive Hardness of Glazes," *Jour. Amer. Ceram. Soc.*, **7** [5] 342–46 (1924).

[3] A. C. Harrison, "A Preliminary Study of the Resistance to Abrasion of Ceramic Glazes, Its Controls and Methods of Determination," *ibid.*, **10** [2] 77–89 (1927).

[4] Edward Schramm, "Sandblast-Abrasion Test for Glazes," *ibid.*, **12** [5] 356–59 (1929).

[5] C. J. Kinzie, "Physical Tests for Vitreous Enamels: I, Determining Physical Properties of Vitreous Enamels," *ibid.*, **12** [3] 188–92 (1929).

up an air pressure in the pipes between the nozzle valve and the main air line. The flow from the main line being shut off, the nozzle valve is opened suddenly, and the amount of abrasion accomplished by the air in the pipe is measured by loss in weight of the specimen. Twenty-mesh Ottawa sand is used as the abrasive. Kinzie[5] used a modification of the Bell Laboratory rotating-disk test, in which the abrasive was placed inside of an enameled cup which was then rotated rapidly for forty-one hours, after which the abrasion was determined from loss in weight.

III. Description of Apparatus

During the course of a recent investigation, it became desirable to determine the comparative abrasion resistance of a number of enamels. Knowledge concerning both surface and destructive abrasion was required. The problem called for a simple, inexpensive machine, flexible, rapid, and requiring a minimum of attention. While all of the test methods described serve admirably for the designed purposes, none of them quite meets the requirements of the problem. It became necessary, therefore, to design and construct a suitable machine to deal with it.

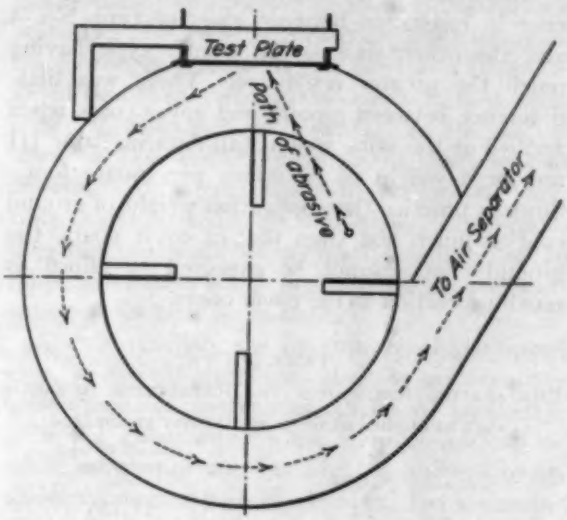

FIG. 1.—Sand-abrasion machine.

The abrasion machine shown in Fig. 1 was evolved as a result of this need. The machine utilizes the centrifugal force of a rapidly revolving horizontal disk to propel the abrasive against the surface under test. The severity of abrasion is controlled by the fineness of the abrasive, Ottawa sand being used for this purpose. Eighty-mesh sand is used for surface abrasion, while 20-mesh sand is used for destructive abrasion.

The machine is simple in principle, consisting of a 12-inch steel disk, carrying eight $^1/_2$- by 3-inch steel flanges mounted alternately, four on each side, revolving at a speed of 1725 r.p.m. inside a metal-lined casing 17 inches in diameter. A 4- by 6-inch sample plate is locked in an opening in the casing. The sand is introduced from a hopper mounted on top of the casing through a $^1/_4$-inch orifice so located as to give maximum efficiency. Approximately 50% of the abrasive strikes the sample plate; one-half of this amount (25% of the total) is concentrated upon 9% of the total abraded area of the plate. The abrasive strikes the plate at an angle of approximately 30° in the area of maximum abrasion. The spent abrasive is exhausted through a port in the rear of the casing into a separating chamber which removes all fine material.

The machine is rapid, requires little attention while in operation, and can be used for either type of abrasion at will by simply changing the abrasive. Tests show the results to be sufficiently uniform for use in general research or control work.

IV. Measurement of Abrasion

For surface-abrasion tests, the Ingersoll glarimeter was used as a measuring device. This instrument proved quite satisfactory as long as the bubble layer of the enamel was not penetrated. Tests were made using 4, 8, and 12 ounces of abrasive on various enamels, and the results were quite consistent.

In determining destructive abrasion, three methods were tried, (1) loss in weight, (2) decrease in thickness, and (3) weight of abrasive required to expose the steel. Since the ultimate requirement of the test is to determine the abrasion necessary for complete destruction of the protective coating, the last method proved the simplest and most effective of the three and was adopted.

V. Surface-Abrasion Tests

The surface-abrasion test consisted of measuring the loss of gloss in the area of maximum abrasion as caused by abrasion with a predetermined quantity of 80-mesh Ottawa sand with the

Ingersoll glarimeter. Since any penetration of bubbles in the enamel by the abrasive made the readings of the instrument somewhat questionable, a series of tests was necessary to determine the quantity of abrasive most suitable for the test. Check tests were made on two plates covered with similar enamel. Five separate points on each plate were abraded with 4, 8, and 12 ounces of sand. A steel template was used to protect all of the test plates except the area of maximum abrasion during the test. This made gloss readings simpler and more accurate and it was possible to use the same plate for more than one test. Results of the test are shown in Table I.

TABLE I

COMPARATIVE ACCURACY OF THE SURFACE ABRASION TEST, WITH VARYING AMOUNTS OF ABRASIVE

	Loss of gloss (%)					
	4 oz. abrasive		8 oz. abrasive		12 oz. abrasive	
Station	Loss (%)	Deviation (%)	Loss (%)	Deviation (%)	Loss (%)	Deviation (%)
Plate No. 1						
1	1.20	0.74	3.82	0.29	6.25	0.03
2	1.84	0.10	4.28	0.17	6.37	0.15
3	2.11	0.17	3.95	0.16	6.21	0.01
4	2.34	0.40	4.26	0.15	6.06	0.16
5	2.21	0.27	4.26	0.15	6.21	0.01
Mean plate No. 1	1.94	0.356	4.11	0.184	6.22	0.072
Plate No. 2						
1	1.95	0.11	3.77	0.04	6.70	0.19
2	1.69	0.15	3.80	0.07	6.38	0.13
3	1.80	0.04	3.91	0.18	6.83	0.32
4	1.69	0.15	3.65	0.08	6.38	0.13
5	2.08	0.24	3.54	0.19	6.29	0.22
Mean plate No. 2	1.84	0.138	3.73	0.112	6.51	0.198
Total readings exceeding limit = 0.5%	1		0		0	

Data compiled from these tests as shown in Table I indicate that only one point out of a total of thirty exceeded the limits of accuracy for the glarimeter. As a test of the method for enamels of different composition, four enamels were tested for surface-abrasion resistance and the results were compared with the scratch hardness as determined by the Mohr system. The results are shown in Table II. Data from both tests would indicate the results from 12-ounce abrasion to be slightly more dependable than the 4-ounce results.

TABLE II

COMPARATIVE RESISTANCE OF SEVERAL ENAMELS TO SURFACE ABRASION

	Loss of gloss (%)		
Enamel	4 oz.	12 oz.	Scratch hardness
1	0.83	3.37	6
2	0.92	6.15	5½
3	0.91	3.42	6
4	1.20	4.37	5½–6

VI. Destructive Abrasion

Destructive abrasion tests were made by abrading the enameled surface with 20-mesh sand until the iron was exposed. Investigation showed that the smallest addition of sand required to make a discernible change in the surface of the enamel was four ounces. This weight was taken as the smallest unit of sand added. Check tests made on the same plate by means of the template described above showed remarkable uniformity; in fact, the results of four trials were identical.

Four types of sheet-steel enamel were abraded to destruction. Table III shows a marked difference in resistance between glass of type No. 4 and the other glasses, the former type having much the greater resistance. There was little difference between ground and cover coats when applied at the same weight (all data in Table III are for a weight of 65 grams per square foot). Since in practice the application weight of ground coats is much less than that of cover coats, the ground coats cannot be expected to afford as much protection as the cover coats.

TABLE III

COMPARATIVE RESISTANCE TO DESTRUCTIVE ABRASION

(Taken as applied at 65 g./sq. ft. over ground coat)

Enamel	Sample	Pounds of sand to destroy (%)
Type No. 1	1	11.125
	2	11.125
	3	9.75
	4	10.94
Type No. 2	1	11.00
	2	11.125
	3	11.75
	4	10.75
Type No. 3	1	10.75
Type No. 4	1	14.75
	2	15.12

VII. Conclusions

The sand-abrasion machine described meets the need for a simple, rapid, flexible test for the determination of abrasion resistance in porcelain enamels. The machine can readily be constructed

and requires no special equipment or special type of test plates. The results check each other surprisingly well. Some work remains yet to be done, such as comparative abrasion at various angles. The machine as it stands today, however, should prove a valuable tool in the hands of any one interested in the abrasion resistance of porcelain enamels.

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THE PLASTICITY OF FINELY GROUND MINERALS WITH WATER*

BY EARL O. WILSON

ABSTRACT

A study is made of the plasticity of finely ground minerals in water. For this purpose a machine was developed to give quantitatively the factors making up plasticity. It is shown that the particle shape is an important factor governing plasticity.

I. Introduction

The plasticity of minerals used in the ceramic industries is of great importance. Such minerals, chiefly the clay minerals, are used in a finely divided condition and are worked or formed while they are moistened with water. In this paper, the term "plasticity" refers to the finely ground mineral with water. Since practically all clayware is first formed while in this plastic condition, it is not too much to say that plasticity is the property of clays which makes possible their utilization in the ceramic industries.

Notwithstanding the importance of this property, at the present time, there is no adequate understanding of the mechanism of plasticity. It is not known why some minerals are plastic while others are not, and, in the absence of an understanding of this mechanism, the quantitative measurement of plasticity has been impossible. Numerous investigations have been made, but the points of view adopted and the results attained show little uniformity or agreement.

To throw more light on this subject, the mechanism of plasticity was studied in this investigation by observing the relation of plasticity to the shape and nature of the mineral particles.[1]

It was assumed that the finely ground particles had the same shape as larger ones of the same mineral and that a water film between the particles was essential for plasticity. It is, of course, recognized that particle shape is only one of the many factors determining plasticity.

It is not possible to give a precise definition of plasticity, but it is well understood by investigators in various fields that the term refers to the property of a material which enables it to be permanently deformed without fracture. To determine what relationship exists between crystal shape and plasticity, a study was made of the plasticity of a number of finely ground minerals of known crystal form.

II. Methods of Test

Various methods of accomplishing this were considered and a torsion method was finally adopted. The machine, as finally constructed, is shown in Fig. 1. A bar of clay is mounted in the jaws, *A*, and twisted at the rate of 3 to 4 revolutions per minute by the motor, *B*. A stress-strain curve is traced on the smoked glass plate, *C*. This machine is so constructed as to be practically frictionless. An important feature is the high natural frequency and the critical damping, *D*, secured, which make possible an instantaneous equilibrium and thus a true picture of the stress-strain relationship. The springs, *E*, of the apparatus were calibrated so that the torque could be expressed in gram-centimeters. Photographic enlargements were prepared, and from these graphical corrections were made so that the curves could be drawn with rectangular coördinates.

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* Scheduled for presentation at the Annual Meeting, American Ceramic Society, Columbus, Ohio, March 31, 1936 (White Wares Division). Received October 3, 1935.

[1] This study followed the work reported by F. H. Norton to the American Ceramic Society at the 1935 Annual Meeting.

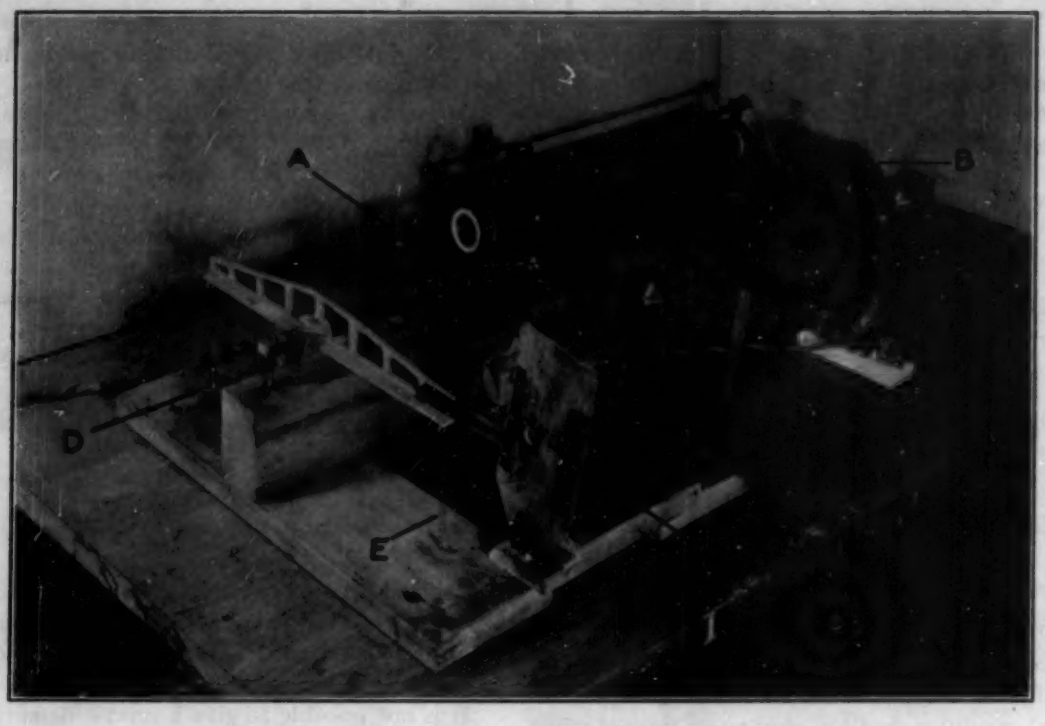

FIG. 1.—Torsion machine for testing plasticity.

The autographic method was used because the clay had to be deformed at a rate comparable with regular working conditions. Low rates permit the water film to move from the high-stressed regions to the low-stressed regions, thus giving misleading values.

III. Preparation of Specimens

Twenty samples of minerals of known crystal structure were ground wet to a degree of fineness approximating that of well-dispersed china clay and brought to a condition of optimum workability by controlling the water content. The

TABLE I

Class	Mineral	Composition	Structure	Cleavage
Clays	English ball clay		Sheet	Perfect basal
	Bentonite		"	" "
	Halloysite	$(OH)_4Al_2Si_2O_5$	"	" "
	English china clay (kaolinite)	$(OH)_4Al_2Si_2O_5$	"	" "
	Pyrophyllite	$(OH)_2Al_2Si_4O_{10}$	"	" "
Sheet structure with OH groups	Brucite	$(OH)_2Mg$	"	" "
	Goethite	$(OH)_2(FeO)_2$	"	" "
	Gibbsite	$(OH)_3Al$	"	" "
	Talc	$(OH)_2Mg_3Si_4O_{10}$	"	" "
	Muscovite	$(OH)_4KAl_2(Si_3Al)O_{10}$	"	" "
Sheet structure anhydrous	Molybdenite	MoS_2	"	" "
	Graphite	C		" "
Perfect cleavage	Galena	PbS		Perfect cubic
	Sphalerite	ZnS		Perfect dodecahedral
One predominant cleavage	Fluorite	CaF		Perfect 111
	Cyanite	$Al_2O{\cdot}SiO_4$		" 100
	Calcite	$CaCO_3$		" 1011
	Gypsum	$CaSO_4{\cdot}2H_2O$		" 010
No definite cleavage	Beryl	$Be_3Al_2Si_6O_{18}$		Poor 0001
	Quartz	SiO		None

fineness was checked with a microscope using an oil immersion lens. The grinding was stopped when the maximum particle size reached 2.5 microns. Test specimens were made by extruding the material through a die under a vacuum and then pressing the resulting bars in a plaster mold to give a circular section. In the case of the nonplastic or very slightly plastic materials, the extrusion apparatus could not be used, and the specimens were made directly in molds. They were 6.4 centimeters in length, 1.1 centimeters in diameter at the circular section, and the distance between chucks in the testing machine was 3 centimeters. After aging twenty-four hours in airtight containers, the specimens were placed in the torsion machine and stress-strain diagrams were obtained.

IV. Results

The minerals used are listed in Table I together with certain of their important properties.

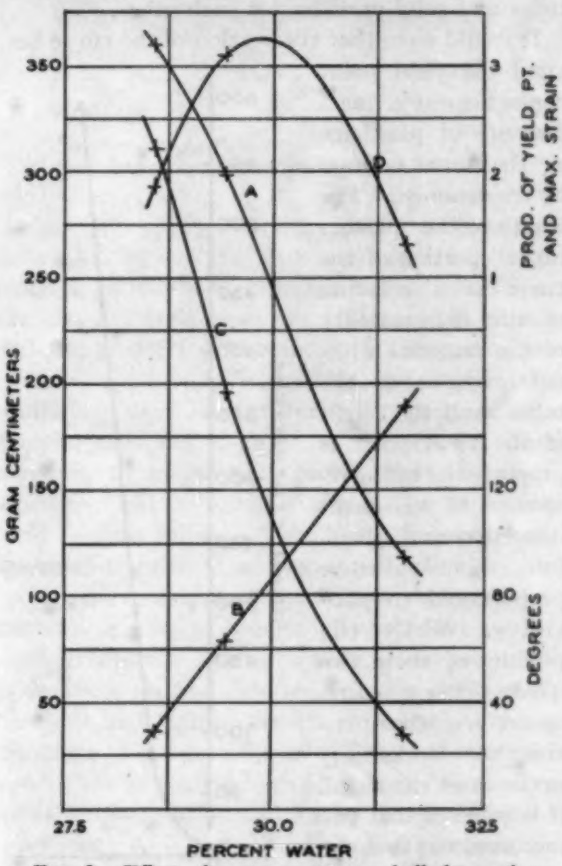

FIG. 2.—Effect of water content on ball clay. *A* = maximum strength; *B* = maximum deformation; *C* = yield point; *D* = product of yield point and maximum deformation.

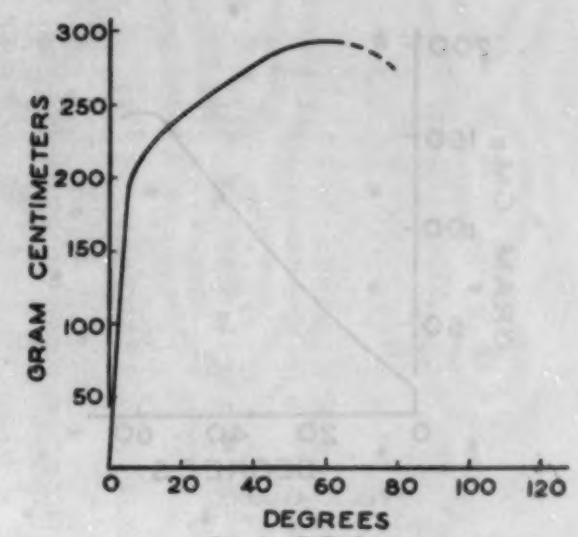

FIG. 3.—Ball clay.

A few typical curves are shown in Figs. 3 to 9, and the results calculated from all the curves, together with certain other properties of the minerals, are shown in Table II. The similarity between these curves and the stress-strain curves of the plastic metals is striking. A curve made with a sample of Plasticene is included for comparison in Fig. 10.

(1) Effect of Water Content

In the case of ball clay and china clay, tests run at more than one water content gave the following results:

(1) The height of the yield point decreases with increasing water content.
(2) The deformability increases with increasing water content; that is, fracture occurs at a greater angular strain.
(3) The maximum strength decreases with increasing water content.
(4) The product of the yield value and deformability reach a maximum at the water content of greatest workability.

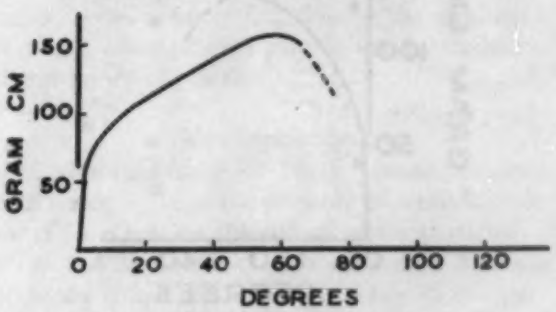

FIG. 4.—China clay.

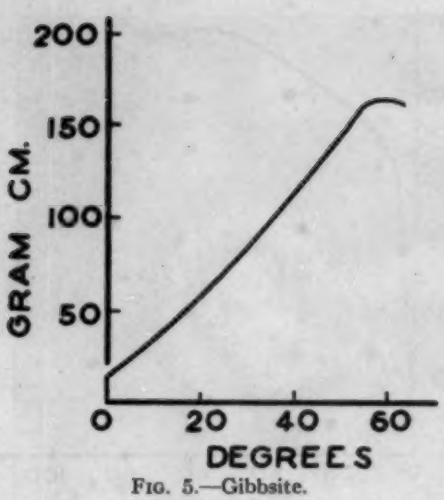

FIG. 5.—Gibbsite.

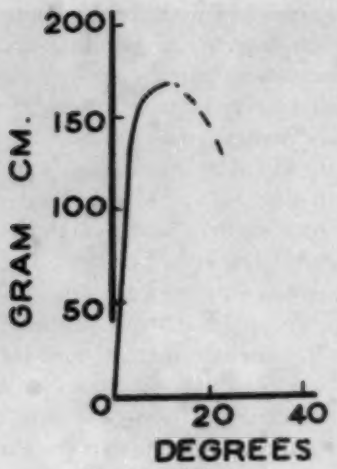

FIG. 7.—Galena.

The above characteristics for ball clay are illustrated by the curves in Fig. 2.

(2) Effect of Crystal Structure

The minerals are grouped in Table I according to their crystal structure and cleavage. The minerals of a single group give similar stress-strain curves, but the groups are each characterized by a separate type of curve.

An understanding of the meaning of the curves may be obtained by considering what happens when the specimen is twisted in the torsion machine. At first the specimen is twisted without permanent deformation and for short intervals of time is "elastic"; then, as the shearing force is increased, a gradual deformation of the material is observed. The rigidity of the water films has been broken, and slippage occurs between the water films and the particles, the particles slipping or rolling over each other to some extent as the water films move. Fracture occurs when the angle of twist is sufficient to overcome the resultant attraction of the water films for solid particles and solid particles for each other.

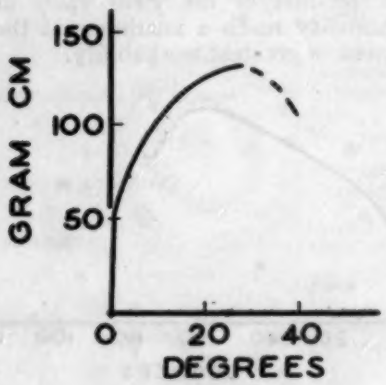

FIG. 6.—Molybdenite.

It would seem that the portion of the curve beyond the yield point comes nearest giving a measure of plasticity as the term is used by the ceramist. The length of the "plastic-range" portion of the curve is a measure of the deformability of the material without fracture; on the other hand, the height of the yield point is proportional to the resistance to permanent distortion and, therefore, should also be proportional to plasticity. While the product of these two quantities corresponds to the plasticity or workability in the cases examined, it is believed that two factors rather than one must be used to define it strictly.

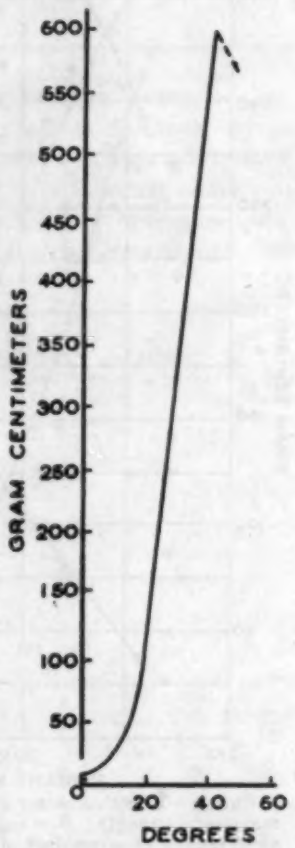

FIG. 8.—Gypsum.

All of the minerals

TABLE II

Material	Water (% wet basis)	Drying shrinkage (%)	Water film thickness (cm. × 10^{-4})	Yield point (g. cm.)	Maximum strength (g. cm.)	Angle of twist (degrees)	Area under curves (sq. in.)	Product of yield point and maximum strain	Dried strength
Ball clay	28.5			317	365	28	2.0	1.80	Strong
" "	29.7			80*	198	65	2.56	1.30	"
" "	29.5			195	290	66	4.00	3.10	"
" "	31.7	7.5	2.0	35	120	150	4.05	1.31	"
China clay	35.2	5.0	3.0	27	82	90	1.64	0.61	"
" "	33.0			51	157	60	1.93	0.72	"
Halloysite	34.4	9.1	2.0	27	75	162	2.90	1.09	"
" "	32.7			82	202	74	3.08	1.47	"
Bentonite	52.9	34.0	0.1†	30	89	74	1.48	0.60	"
Pyrophyllite	40.6			32	160	86	2.61	.69	Fairly strong
" "	42.0	4.5	3.0	15	115	88	1.86	.33	" "
Brucite	37.8	1.5	1.0	12	115	87	1.50	0.26	" "
Goethite	19.1	1.75	1.0	12	110	104	2.60	.32	" "
Gibbsite	28.8	5.2	3.0	15	163	58	1.19	.22	" "
Talc	42.5	4.0	2.0	48	102	34	0.71	.41	Strong
Muscovite	38.8	4.25	2.0	12	80	48	0.70	.15	"
Molybdenite	27.2			57	132	28	0.74	0.40	Weak
Graphite	46.6	1.75	1.0	24	105	28	0.50	.17	Very weak
Sphalerite	15.8	0.7	2.0	11	530	42	2.14	0.12	Weak
Galena	12.9	0.5	1.0	132	170	14	0.56	.46	"
Fluorite	15.9	0.15	0.1	11	530	44	1.58	0.12	Very weak
Cyanite	18.7	0.50	0.3	10	312	47	1.15	.12	Weak
Calcite	17.0			5	465	32	0.91	.04	"
Gypsum	42.0	1.5	1.0	10	600	42	2.10	.11	"
Beryl	25.7	0.0	0		305	5	0.17	0.0	Very weak
Flint	22.3	0.0	0		360	3	0.05	.0	" "
Plasticene				97	167	140	5.44	3.4	

* Samples not aged.
† Bentonite may be prepared with much thicker films at higher water content.

tested having a sheet structure and the accompanying perfect basal cleavage showed plasticity; the clay minerals have the highest yield points and the greatest deformability. The curves for gibbsite, goethite, pyrophyllite, and brucite are similar to them except for lower yield points. Molybdenite has a curve similar to the clay minerals, as might be expected from the sheet structure, but of smaller area. On the other hand, galena shows a high yield point and small deformability due to interlocking of the cubes.

Gypsum is a typical example of the group of minerals having a definite cleavage but not a sheet structure. The water films are weakly held as shown by the low yield points. The short plastic range and high maximum is probably due to the shape of the particles as well as to the magnitude of the attractive forces involved. After the water films are broken, the irregular-shaped particles touch each other at points and interlocking effects and frictional resistance occur.

In the last group (no definite cleavage), this effect is even more pronounced. Beryl and quartz show no yield point and no linear drying shrinkage. Water films are completely absent and we have the effect of interlocking grains and frictional resistance as soon as the deforming force is applied. The curves rise elastically to a high maximum with very slight angular deformation.

It would be of considerable interest to be able to predict the plastic qualities of a mineral from some particular characteristic of the stress-strain diagram. From the discussion, it is evident that the height of the yield point and the length of the curve to the point of fracture are the significant factors. Their product may be taken as a tentative measure of plasticity.

V. Conclusions

(1) The plasticity of finely ground minerals with water is due to the presence of stable viscous water films held on the surface of the particles.

(2) The formation of such water films depends upon the shape and surface activity of the particles.

(3) Minerals with a perfect cleavage have a higher plasticity than those without. In general, those which have a platelike structure are more plastic than those which have a perfect cleavage in some other crystal form.

(4) The clay minerals are more plastic than other minerals having a platelike structure. This is due to the greater surface activity of such minerals. The OH groups on the surface of the kaolin minerals may be a cause of this great surface activity.

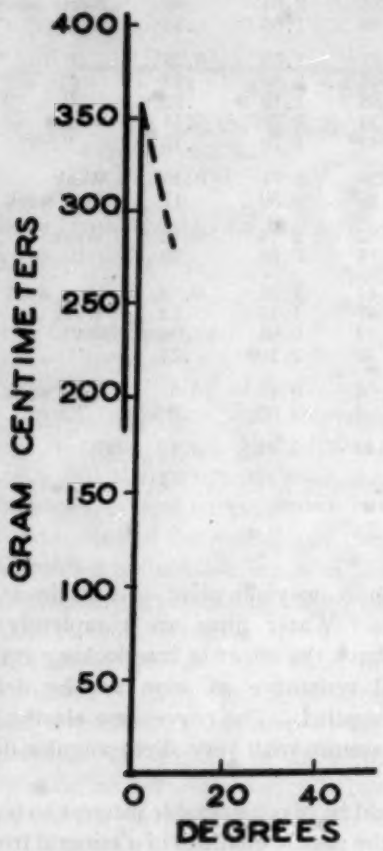

FIG. 9.—Flint.

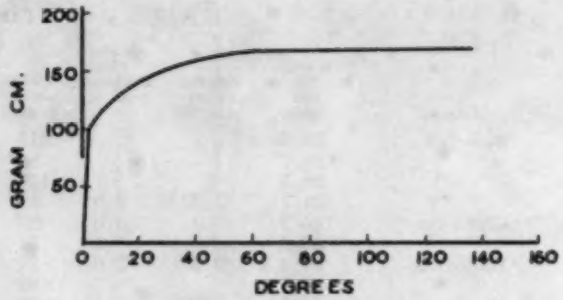

FIG. 10.—Plasticene.

(5) Minerals having one predominant cleavage show some plasticity over a very limited range of water content.

(6) Minerals having no definite cleavage have no plasticity.

(7) Stress-strain diagrams of the type obtained in this investigation are suitable for the study and interpretation of the plastic properties of such mineral-water pastes.

(8) The stability of the water films is proportional to the height of the yield point on such diagrams.

(9) The total deformability is proportional to the angular strain at fracture.

(10) Plasticity is roughly proportional to the product of the yield value and the angular strain at fracture.

Acknowledgment

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THE INFLUENCE OF DRYING TREATMENT AND BISCUIT STORAGE ATMOSPHERE ON THE PHYSICAL PROPERTIES OF A SEMIPORCELAIN BODY*

By Horace L. Latimer and Arthur S. Watts

Abstract

This investigation employed the following drying tests: (1) in the presence of $CaCl_2$, (2) in air circulated at 100°F, (3) in air circulated at 225°F, and (4) in a humidity drier, employing 129°F. dry bulb, with 85% humidity for two days and decreasing humidity to bone dryness in five days. The trials were fired under regular plant conditions and stored as follows: (1) in a closed chamber with adequate supply of $CaCl_2$, (2) in outside weather, winter and spring, (3) alternate soaking in water for two days and drying to 5% of total absorption for the period of test, and (4) in a saturated atmosphere. Data on modulus of rupture, absorption, and porosity are assembled in tables and graphs for comparison, indicating marked influences on these properties both by drying and storage treatments. Explanations of the results are suggested.

I. Introduction

The purpose of this investigation was to ascertain (*a*) what changes take place in the porosity, absorption, and strength of a biscuit semiporcelain body when stored in various atmospheres and (*b*) what influence the drying treatment used in the process might have on such changes.

II. Method of Procedure

A commercial semiporcelain body[1] was used for this investigation. An auger machine was used for extruding the trial pieces, which were 1-inch solid cylinders and 7 inches long. All test pieces were extruded from one batch of the body. The pressure in the auger machine was maintained as uniform as possible during the forming process.

Eight hundred and thirty-two (832) test bars were prepared, arbitrarily divided into four lots of 208 bars each, and appropriately marked for identification in the subsequent tests. Each lot of 208 bars was subjected to one of the four definite drying treatments used. After drying, all bars were fired at one time under uniform conditions in a commercial car tunnel kiln.

After firing, 16 bars from each original lot that had been subjected to a definite drying treatment were tested for strength, absorption, and porosity to compare the effects of the drying treatment upon the initial properties of the fired body. The results of these tests are given in column 3 of Table I.

The remaining bars (192) in each of the original lots were then divided into four batches of 48 bars each. One batch from each original lot (dried under a definite condition) was placed in each of the four different types of storage systems. At the end of one, four, and six months, 16 bars from each batch were taken out of each of the four storage units and tested for strength, absorption, and porosity. The average values are recorded in Table I.

III. Description of Drying Methods

(1) $CaCl_2$ Treatment

The test bars were placed on trays which were then stacked in a tight metal container. Alternate trays in each stack were filled with dry $CaCl_2$ to absorb the moisture evaporated from the trial pieces. Sufficient $CaCl_2$ was used so that at the end of the seven days of drying there was no evidence of dampness in the $CaCl_2$.

(2) Low-Temperature Drying

Test bars were dried in a gas-heated drier maintained at 100°F. Outside air was drawn into the drier and circulated at all times.

(3) Humidity Drying

Test bars were dried in a Proctor and Schwartz laboratory-type humidity drier. The temperature and humidity were increased from atmospheric conditions to 129°F (dry bulb) and 123°F (wet bulb). The humidity was 85%. This

* Presented at the Annual Meeting, American Ceramic Society, Cincinnati, Ohio, February, 1934 (White Wares Division). Received January 20, 1934.

[1] This investigation was made possible through the courtesy and coöperation of the Crooksville China Co. of Crooksville, Ohio, which Company provided the plastic body from regular prepared stock and fired the test pieces with its regular biscuit ware.

TABLE I
TEST DATA

Test (1)	Drying condition (2)	Storage Conditions: Dry atmosphere: Initial (3)	1 mo. (4)	4 mo. (5)	6 mo. (6)	Natural weather: Initial (7)	1 mo. (8)	4 mo. (9)	6 mo. (10)	Soaking and drying: Initial (11)	1 mo. (12)	4 mo. (13)	6 mo. (14)	Saturated atmosphere: Initial (15)	1 mo. (16)	4 mo. (17)	6 mo. (18)
Modulus of rupture	A	4200	4120	3490	4085	4200	3530	3770	3515	4200	3650	3595	3770	4200	3590	3485	3870
	B	5670	5435	5235	5405	5670	4525	4910	4595	5670	4765	4710	4810	5670	4600	4565	5020
	C	5400	5525	5200	5395	5400	4915	4885	4855	5400	5075	4835	4455	5400	4970	4890	4810
	D	5450	5395	5015	5260	5480	4510	4325	4485	5480	4195	4260	4730	5480	5065	4675	4410
Absorption	A	9.48	9.21	9.74	10.17	9.48	8.97	9.47	9.52	9.48	9.49	9.64	9.81	9.48	7.60	9.63	9.91
	B	9.70	9.73	9.74	10.53	9.70	9.47	9.84	9.29	9.70	9.40	9.53	9.14	9.70	7.15	9.75	9.96
	C	10.04	10.09	10.60	10.63	10.04	9.93	9.75	10.12	10.04	9.93	10.35	10.27	10.04	9.90	10.05	10.35
	D	10.57	9.89	10.19	11.08	10.57	8.22	9.86	10.27	10.57	10.25	10.40	9.79	10.57	7.69	10.30	10.66
Porosity	A	28.35	35.35	35.20	32.80	28.35	21.00	31.30	33.70	28.35	33.80	33.20	33.90	28.35	12.50	36.30	33.20
	B	28.75	36.25	34.00	24.75*	28.75	18.50	32.40	32.95	28.75	32.20	34.30	33.25	28.75	15.60	33.25	34.15
	C	32.60	33.40	34.85	34.45	32.60	17.80	34.15	34.10	32.60	30.80	35.40	35.35	32.60	21.10	37.25	35.05
	D	31.70	34.70	34.00	35.40*	31.70	13.90	34.60	35.15	31.70	33.95	36.95	33.90	31.70	17.40	39.85	35.60

Drying conditions
A, dried over $CaCl_2$
B, slow drying at 100°F
C, humidity drying
D, fast drying at 225°F

Values of data in table
Modulus of rupture (lb./sq. in.)
Absorption (% of dry wt.)
Porosity (% of bulk vol.)

* Check for interchange.

NOTE: Columns 3, 7, 11, and 15 have the same values; the duplication is to permit easy comparison of values.

drying condition was maintained for two days. The humidity was then gradually decreased during the next five days. The bars were bone dry at the end of this period.

(4) High-Temperature Drying

Test bars were dried in a gas-heated drier, maintained at 225°F. Outside air was drawn into the drier and circulated constantly.

IV. Description of Storage Systems

(1) $CaCl_2$ Treatment

Test bars were stored in a tight metal chamber containing an adequate supply of $CaCl_2$ to insure a dry atmosphere within the storage space.

(2) Natural Weathering

Test bars were placed in trays and then exposed to the weather during the winter and spring.

(3) Soaking and Drying Treatment

Test bars were soaked in water at room temperature for 48 hours and then allowed to dry in the open air until the moisture content was reduced to approximately 5% of the total absorption. This procedure was continuously repeated during the storage period.

(4) Saturated-Atmosphere Treatment

Test bars were placed in a storage chamber lined with slabs of plaster of Paris that were kept saturated with water at all times to provide a saturated atmosphere at room temperature.

V. Test Methods

(1) Strength

The modulus of rupture was determined from data obtained in transverse-load breaking tests made on a standard Riehle testing machine used in the following formula:

$$\text{Modulus of rupture} = \frac{8\,Pl}{3.14d^3}$$

Where P = breaking load (lb.).
l = span (in.) (5 in.).
d = diameter of bar (in.).

(2) Absorption

The absorption of the trial pieces was determined by the standard method described in the

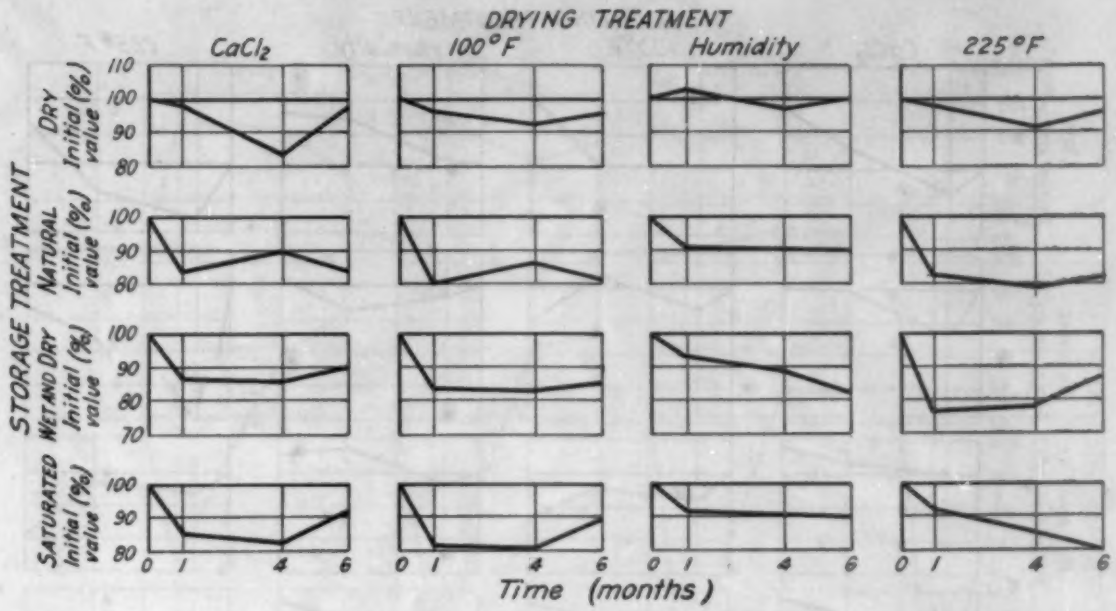

FIG. 1.—Percentage change in modulus of rupture values.

Standards Report of the American Ceramic Society.[2]

(3) Porosity

The porosity of the trial pieces was determined by means of the gas-expansion type of porosimeter described by MacGee.[3]

VI. Data

The data obtained in all of the tests made are presented in Table I. The values noted are the average of the test data obtained from not fewer than 14 trial pieces in each of the tests. In no case were the deviations from the average values greater than ordinarily allowed in test work of this character.

Figures 1, 2, and 3 indicate the percentage changes in the original values for strength, absorption, and porosity of various batches dried by different methods when subjected to various storage treatments for different time periods. The values have been connected by lines to indicate more clearly the changes taking place.

VII. Results

(1) Effect of Drying Treatment

Test pieces dried over $CaCl_2$ had the lowest strength, absorption, and porosity values, and the absorption and porosity values for pieces dried slowly at 100°F are also low. All other values are fairly consistent within experimental limitations.

(2) Effect of Storage Conditions

In general the data indicate that the strength of the body is reduced during the first month or two of storage and in most cases there is a partial recovery of strength during the next four months. Bars subjected to humidity drying had the least loss of strength in storage but showed practically no tendency to recover any lost strength as storage was prolonged. Test bars stored in a dry atmosphere had little loss of strength during the first month or so of storage but recovered a major portion of the loss at the end of six months.

In all but a few cases the absorption of the body was decreased after one month of storage. This was followed by an increase in absorption values as the storage time was increased. At the end of a six months' storage period, the absorption values for the test pieces were greater than the initial values except in a few cases.

The porosity of the test pieces stored under natural weathering conditions or in a saturated atmosphere decreased after one month of storage. At the end of the four- and six-month storage periods, however, the porosity of the test pieces was greater than that before storage. Test

[2] *Jour. Amer. Ceram. Soc.*, 11 [6] 456–57 (1928).
[3] A. E. MacGee, "Several Gas Expansion Porosimeters," *ibid.*, 9 [12] 814–22 (1926).

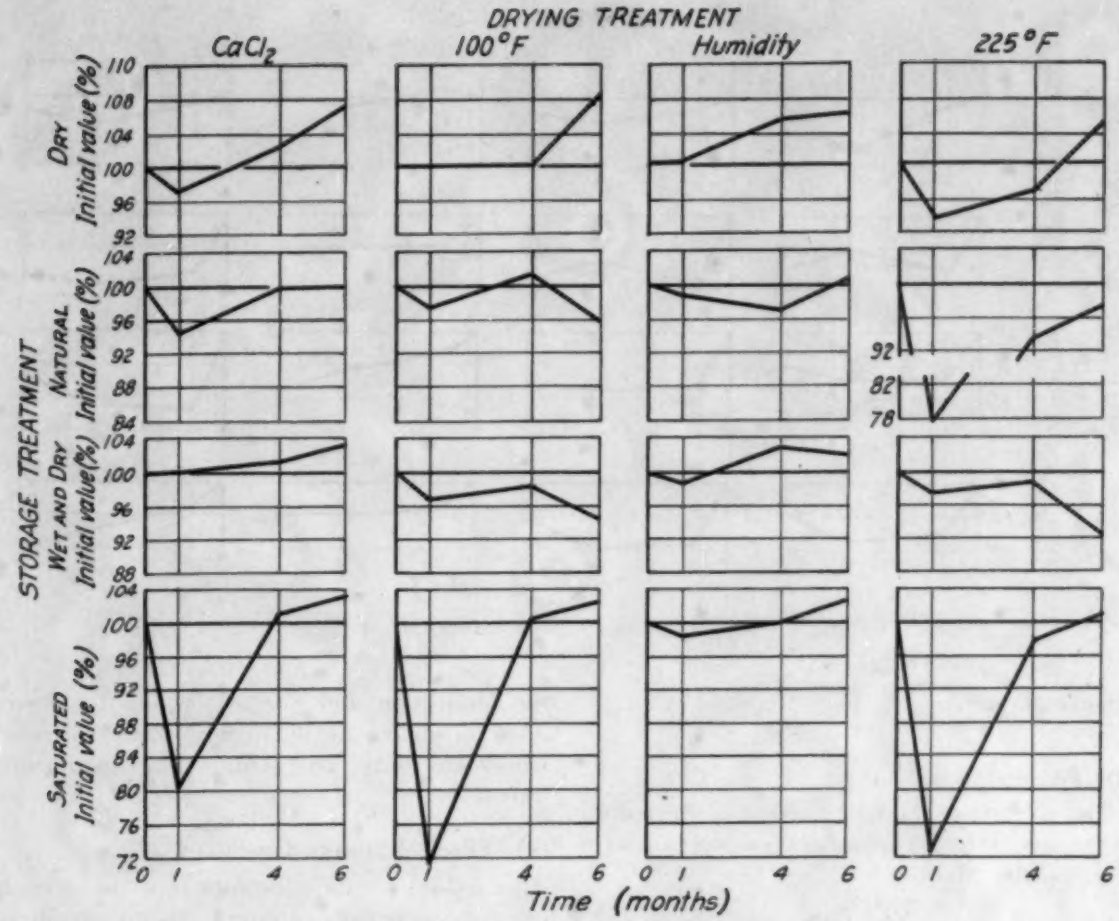

FIG. 2.—Percentage change in absorption values.

pieces stored in a dry or an alternate soaking and drying system showed no decrease in porosity during storage, except in one case. Furthermore, the porosity of these test pieces was greater than the initial value at the end of a six months' storage period.

VIII. Discussion of Results

(1) Strength Changes

The loss and subsequent recovery in the strength of the body during several months of storage can possibly be explained on the following basis:

At the maturing temperature of the body, when the glassy phase is in a melted state, the various constituents may be considered to be in equilibrium with each other and all strains in the body are eliminated. As a piece cools, however, strains develop due to the differences in the rate of cooling between the inside and the outside of the piece. As a result, the piece as it leaves the kiln has tension stresses in its outer layers or shell while the interior is under compression. The piece, when subjected to a bending test, fails by reason of the tension stresses on the side opposite the load. Hence at the time of breaking, the stress causing failure is the sum of (*a*) the tension stress due to the applied load and (*b*) the residual tension stress in the outer shell of the piece.

The following phenomena may take place during the storage period and would explain the results obtained:

(*a*) A change in the structure of the body may take place, due to the action of such agencies as solution, disintegration, and crystal growth. The adsorption of water from the air by a porous body promotes such action. The effect of such changes would be to reduce the strength of the body.

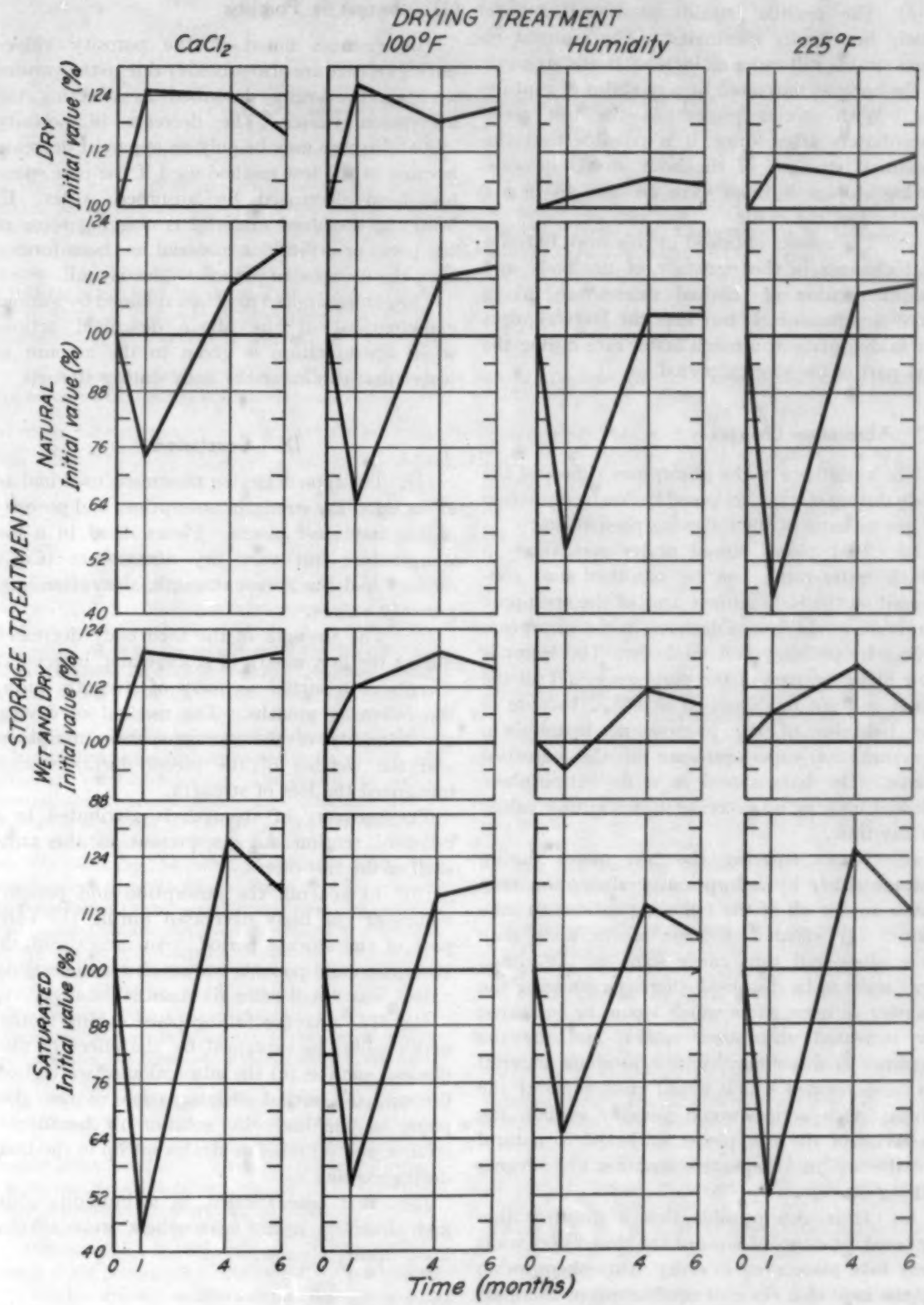

FIG. 3.—Percentage change in porosity values.

(*b*) The residual strains in the body are slowly but finally eliminated. The removal of these strains will cause an increase in the strength of the body as measured by a modulus of rupture test. With strains present in the test piece immediately after firing, it is possible that the measured strength of the body would increase during storage if there were no changes in the structure of the body.

(*c*) The results obtained in this work indicate that changes in the structure of the body and the elimination of residual strains are taking place simultaneously, but that the body changes are taking place at a much faster rate during the first part of the storage period.

(2) Absorption Changes

The variations in the absorption values of the body during storage are possibly due to the action of one or more of the following phenomena:

(*a*) Test pieces stored under conditions in which water-vapor can be adsorbed and condensed on the large surface area of the open-pore structure would show a decrease in the absorption values by ordinary test methods. The water is now filling up part of the pore space and all the water will not be driven off at 105°C because of the behavior of the hygroscopic material in lowering the vapor pressure of the adsorbed water. The bars stored in a dry atmosphere showed little or no decrease in absorption values at any time.

(*b*) Water entering the test pieces during storage either by adsorption or absorption may cause any or all of the following actions to take place: (1) solution of some of the body may take place and thus cause some of the closed pore walls to be dissolved, thereby increasing the number of open pores which would be indicated by increased absorption values, and (2) the presence of water may cause crystalline material to be developed which would close some of the pores; such action would possibly explain the behavior of the test pieces subjected to natural weathering and repeated soaking and drying during storage.

(*c*) It is also possible that a disintegration or breaking down of some of the closed pore walls may take place even in a dry atmosphere owing to the lack of a state of equilibrium in the glass phase of the body.

(3) Changes in Porosity

The changes noted in the porosity values during storage are also probably due to the various agencies previously described as affecting the absorption values. The decrease in porosity and absorption may be only an apparent decrease because of the test method used if the pore space has been decreased by adsorbed water. If, however, dissolved material is clogging some of the pores or crystalline material has been formed then the decrease in porosity value is real.

The changes noted may be explained by various combinations of the above described actions when consideration is given to the amount of water that can enter the body during storage.

IX. Conclusions

(1) The type of drying treatment used had an effect upon the strength, absorption, and porosity of the fired test pieces. Pieces dried in a low temperature but very dry atmosphere ($CaCl_2$ drying) had the lowest strength, absorption, and porosity values.

(2) The strength of the fired body decreased during the first month of storage and, in general, there was a partial recovery of strength during the following months. The method of drying, the humidity of the storage-space atmosphere, and the wetting of the pieces during storage influenced the loss of strength.

The recovery of strength is attributed to a relief of tension stresses present in the outer shell of the test pieces.

(3) In general, the absorption and porosity values of the body decreased during the early part of the storage period. An increase of the absorption and porosity values above the original values was noted after six months' storage.

(4) The changes taking place during storage may possibly be explained by the effect of phenomena such as (*a*) the adsorption of water from the air, (*b*) partial disintegration of the glass phase of the body by solution or because of strains, and (*c*) relief of strains set up in the body during cooling.

(5) Test pieces dried in a humidity drier and stored in a dry atmosphere were affected least during storage.

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CERAMIC ABSTRACTS

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The bold-face number following the journal name is the volume; the issue number is in brackets, followed by the page numbers, then the year in parentheses.

Vol. 15 **April, 1936** **No. 4**

Abrasives

Advance in disk grinding. Anon. *Can. Machinery*, **46** [11] 16–17 (1935).—Various grinding operations and abrasive disks are discussed. Illustrated. W.H.B.

Industrial America, its way of work and thought: XII, Norton abrasives at work in industry. Arthur Pound. *Atlantic Monthly*, **156** [6] 761–68 (1935).—P. presents a history of the abrasive industry and the industrial and domestic services rendered by abrasive products. Grinding is described as the common denominator of mass production and refined fabrication. The growth and present organization of Norton Company are described. A.P.

Influence of particle size, shape, aggregation, and hardness on the abrasiveness of fine powders. M. L. Smith. *Jour. Soc. Chem. Ind.*, **54** [34] 269–75 (1935).—An apparatus is described by which the abrasion of very fine powders used for polishing can be quantitatively measured and compared. This apparatus could also be applied to testing the abrasive- and scratch-resistance of surfaces. The influence of particle hardness is shown by tests on various fine powders of measured particle-size distribution. A rough quantitative measure of depth of scratching is described, and the existence of a particle diameter below which visible scratching does not occur under the present experimental conditions is pointed out. G.R.S.

Polishing and buffing operations in electrical manufacturing. Waldo Hutchinson. *Elec. Mfg.*, **13**, 26–28 (Oct., 1934); *Met. Abs.*, **6** [7] 288 (1935).—Theoretical considerations and actual practice are given for commercial polishing of various metal plates.

Polishing-wheel development. Henry R. Power. *Metal Cleaning & Finishing*, **8** [1] 31–32 (1936).—A radically different fiber polishing wheel, the Columbian fiber polishing wheel, is already accepted for polishing diversified products. Its construction and uses are described. E.J.V.

PATENTS

Abrasive-coated articles. Carborundum Co., Ltd. Brit. 440,569, Jan. 15, 1936 (Oct. 12, 1933).

Abrasive machinery. W. H. Sabine, Jr. Brit. 441,022, Jan. 22, 1936 (July 13, 1934).

Abrasive wheel and method of making. R. C. Benner and W. G. Soley (Carborundum Co.). U. S. 2,028,183, Jan. 21, 1936 (April 18, 1930). An abrasive wheel has a metal disk attached to each lateral face thereof by cement containing a phenolic condensation resin and granulated filler in sufficient proportion to modify the character of the resin, whereby the cement has a higher modulus of elasticity than the abrasive wheel.

Cutting and abrading machine and process. J. F. Williams (General Motors Corp.). U. S. 2,030,023, Feb. 4, 1936 (March 5, 1927).

Grinding machine. William Arter and Harry Arter (Arter Grinding Machine Co.). U. S. 2,028,642, Jan. 21, 1936 (Sept. 24, 1930). Paul Brühl and Franz Neugart. U. S. 2,028,315, Jan. 21, 1936 (April 14, 1933). S. J. Harley and Coventry Gauge & Tool Co., Ltd. Brit. 440,389, Jan. 8, 1936 (March 21, 1934).

Grinding or polishing machines. B. Walters. Brit. 440,854, Jan. 22, 1936 (Dec. 22, 1934).

Grinding or refining machines for paper pulp. F. Lord and A. C. Wilby, Jr. Brit. 441,316, Jan. 30, 1936 (Nov. 29, 1934).

Grinding of rotating eccentric knives. W. E. Molins, H. B. Molins, and M. H. Isaacs. U. S. 2,028,681, Jan. 21, 1936 (Jan. 11, 1934).

Honing tool. K. W. Connor and Albert Bleasdale (Micromatic Hone Corp.). U. S. 2,028,648, Jan. 21, 1936 (July 15, 1932).

Hydraulic ball race grinder. A. P. Steiner, E. P. Wine, and H. E. Balsiger (Landis Tool Co.). U. S.

2,029,510, Feb. 4, 1936 (Aug. 30, 1929) and U. S. 2,029,511, Feb. 4, 1936 (Oct. 22, 1929).

Machine for producing screw threads by a grinding operation. S. J. HARLEY AND COVENTRY GAUGE & TOOL CO., LTD. Brit. 440,255, Jan. 8, 1936 (March 21, 1934).

Method and apparatus for lapping antifriction bearings. C. I. LOTT. Brit. 440,777, Jan. 15, 1936 (May 17, 1935).

Method of measuring the hardness of abrasive disks. KARL GEPPERT (Kugelfischer Erste Automatische Gusstahlkugelfabrik vorm. F. Fischer). U. S. 2,029,066, Jan. 28, 1936 (Oct. 31, 1934). A method of measuring the hardness of abrasive disks or plates consists in applying a sheet of perforatable material to the surface of the disk or plate, driving a conical impact pin through the sheet into the plate or disk by a standardized driving force, and measuring the diameter of the perforation in the sheet.

Method of treating crystalline abrasives and treated product. C. R. WALKER (Abrasive Products, Inc.). U. S. 2,029,253, Jan. 28, 1936 (Aug. 30, 1935). A step in the method of producing uncrushed crystalline abrasive consists in subjecting it to sudden extremes of temperature change to produce a reaction effective to cause the material to fracture along natural cleavage planes and to be capable of ready crushing without destruction of the naturally sharp cutting edges at such planes of fracture.

Reinforcement of abrasive wheels. CARBORUNDUM CO., LTD. Brit. 441,406, Jan. 30, 1936 (July 20, 1934).

Art and Archeology

Archaic Greek statuettes. CHRISTINE ALEXANDER. *Bull. Met. Mus. Art.*, **30** [9] 178–79 (1935).—Three new examples have been added to the Museum collection of archaic terra cottas. These are probably from western Sicily. One is a goddess sitting on a throne, and another is a maiden standing erect with both hands at her sides. The modeling of the hair and draperies is very carefully done. This one was meant to serve as a scent bottle. The third statuette, of Aphrodite holding a pigeon, is also well done. A.A.A.

Art of Sweden. R. HOPPE. *Studio* [London], **109** [502] 3–29 (1935).—The article includes an appreciation of present-day Swedish glass and ceramics. The Orrefors glass factory makes a remarkable contribution to the industry, and in coöperation with the artists Edward Hald and Simon Gaté, maintains a high artistic quality which characterizes the household as well as the decorative ware. In ceramics the Gustafsberg and Gefle factories are the most outstanding; the latter is the source of some of the world's finest porcelain. Wilhelm Kage and Ivar Johnsson are important artists to the ceramic industry. The cooperation between prominent artists and great industrial undertakings is led by the Swedish Association of Arts and Crafts. Illustrated. G.H.A.

British art in British pottery. G. M. FORSYTH. *Jour. Roy. Soc. Arts*, **82** [4282] 104–15 (1934); for abstract see *Ceram. Abs.*, **14** [4] 86 (1935). H.E.S.

British art in industry. W. GAUNT. *Studio* [London], **109** [503] 55–70 (1935).—Illustrated. G.H.A.

Cash value of design. WALTER TEAGUE. *Arts & Dec.*, **43** [6] 34–35, 48 (1936).—Kitchen sinks and pickle bottles are art as well as painting and sculpture. If a thing is made well enough, it is fine art and beautiful and the vast output of everyday art is far more important to the general run of citizens than the fraction of artistic total shut away and visited so rarely. That public taste is always bad is an alibi to excuse abortive, clumsy efforts. Illustrated. E.B.H.

Ceramic sculpture from the Robineau Exhibition. ANON. *Design*, **37** [6] 16–19 (1935).—Four pages illustrate ceramic sculpture from the Robineau Exhibition. E.B.H.

Chelsea porcelain clocks. BELLAMY GARDNER. *Connoisseur*, **96** [412] 312–14 (1935).—G. describes and illustrates a group of white Chelsea cupids which surmounted a clock and several clocks of Chelsea with the groups of figures in place. E.B.H.

Chinese art. G. SHERINGHAM. *Studio* [London], **111** [514] 3–14 (1936).—Characteristics of Chinese art are (*a*) reverence for tradition, (*b*) the underlying meaning, and (*c*) significance of color. European and American collectors appreciate Chinese pottery and porcelain more than any other branch of Chinese art; in China, however, ceramics occupy the same relative position to the other arts as our own ceramics do with us. The Chinese appreciate their carved glass and porcelain by touch as well as sight. Illustrated. G.H.A.

Cymbeline's temple, Colchester. ANON. *Discovery*, **16**, 342–43 (Nov., 1935).—Amphoras, pottery lamps, etc., have been found at the Romano-British temple of Camulodunum. H.H.S.

Designs for mass production. ANON. *Design*, **37** [5] 14–15 (1935).—Four sets of tableware shown were designed by Viktor Schreckengost for the American Limoges China Co., Sebring, Ohio. E.B.H.

Developing the intelligent consumer of art. MARIE J. DOLLARD. *Design*, **37** [7] 28 (1936).—A group of ceramic figures by a student of Myrtle M. French at the School of the Art Institute, Chicago, illustrates an article endorsing a course in the public schools which develops intelligent consumers of art, thus necessitating more intelligent producers. Such a course, meeting the needs of the untalented students, is under way at the Alderdice High School, Pittsburgh. E.B.H.

English design in glassware. J. H. HOGAN. *Jour. Roy. Soc. Arts*, **83**, 426–38 (1935); *Jour. Soc. Glass Tech.*, **19** [74] A228 (1935).—The history of glassmaking in England is briefly discussed. The great revival of glassmaking between 1660 and 1676, out of which the English tradition grew, was the outcome of the general impetus of culture after the barren period of the civil war and the Puritan domination. The chief characteristics of the English style are summarized, and the development of bottle design discussed. About 1695, 240,000 dozens of bottles were made in England every year. The Excise Act of 1745 did great harm to the glass industry, the oppressive duties imposed hampering English glassmaking for a century. British glassmakers now tend to depend more on design and form, and especially on good proportions, rather than on decora-

tion. At the present time there is need for encouragement rather than condemnation.

Fourth Annual Robineau Memorial Ceramic Exhibit. R. GUY COWAN. *Design*, **37** [5] 8–11 (1935); *Art*, **28** [12] 756–57 (1935).—Pieces having "gift shoppe" or "Wiener Werkstatte" characteristics were condemned by the judges. Recognition of the exhibit as the official ceramic show of the American Ceramic Society, the holding of the First Fall Meeting of the Art Division of the Society at Syracuse at the time of the exhibition, and converting the show into a traveling exhibit for the winter have increased its influence. See also *Ceram. Abs.*, **15** [1] 4 (1936).

E.B.H.

Greek terra cotta relief. CHRISTINE ALEXANDER. *Bull. Met. Mus. Art*, **30** [8] 165 (1935).—An unusual terra cotta group is shown in the Room of Recent Accessions. It is related in style to the Tanagra statuettes and dates from the 4th Century B.C. The color is well preserved. A.A.A.

History of the York school of glass-painting: XIII, Sources of glass used in York work. J. A. KNOWLES. *Jour. Brit. Soc. Master Glass-Painters*, **6**, 32–48 (1935–36); *Jour. Soc. Glass Tech.*, **19** [75] A322 (1935).—A small proportion of the white glass used in medieval windows was made in England; the whole of the colored glass was imported from the Continent. York glass men generally used Rhenish glass, which could be imported with less difficulty than French. York windows which date about 1470 contain very little ruby glass. In later times York glass painters appear to have made some glass, either as a hobby or in an experimental way. Henry Gyles (1645–1709), William Peckitt of York (1731–95), and J. Barnett (about 1821) are referred to. **XIV, Effects of the plague, called the Black Death, on the York school of glass-painting.** The Black Death visited Yorkshire in 1349 and on subsequent occasions, notably in 1361. A large number of artists and craftsmen, including glass painters, were victims of the epidemic, and the development of architecture and its dependent arts was arrested. The number of glass painters who migrated to York was probably very small. Mention is made of Johannes de Ireland (1352), Ricardus de Welles (1359), and John Thornton of Coventry, who came to York in 1405. John of Winchester, who in 1363 executed work for Durham Abbey, was probably another fugitive from the south. John Burgh worked for the Minster at York as late as 1419. Contemporary York work was inferior to that being done by Thomas, the glass painter of Oxford, at Winchester and elsewhere. Illustrated. For Part **XII** see *Ceram. Abs.*, **14** [6] 136 (1935).

Medieval glass in Holme-by-Newark Church, Nottinghampshire. N. TRUMAN. *Jour. Brit. Soc. Master Glass-Painters*, **6**, 4–15 (1935–36); *Jour. Soc. Glass Tech.*, **19** [75] A322 (1935).—An account is given of the reconstruction and repair of the old glass in Holme Church. Part of the glass used came from the now ruined church of Annesley. Illustrated.

New sculptural glass panel at Radio City. ANON. *Design*, **37** [5] 31 (1935).—The world's largest sculptural glass panel, 16 ft. by 11 ft., whose casting and installation required new technics, has been placed in Rockefeller Center. It is the work of Attillio Piccirilli. An unusual type of glass specially treated to reduce transparency was used by Corning Glass Works, the makers. By a hand-process known as "gathering," the glass was put into the molds in small quantities in such a way as to cause bubbles and other imperfections which break up the crystal clearness of the glass, giving it the effect of fluidity and molding and the general appearance of a huge slab of onyx.

E.B.H.

Physical laboratory at the National Gallery, London. F. IAN G. RAWLINS. *Sci. Progress*, **30**, 236–42 (Oct., 1935).—The equipment of the laboratory is described and collaboration between artist and scientist discussed.

H.H.S.

Pottery and what the public wants to-day. R. COPELAND. *Jour. Roy. Soc. Arts*, **82** [4260] 904–18 (1934).—The Exhibition of British Industrial Art at Burlington House is lauded as a movement to correlate art and industry. The history of the pottery crafts is traced and illustrated from early Persian, Egyptian, and Greek, through Roman, Chinese, and early European times to present-day English practice. The introduction of tea into England is said to have given the greatest impetus to the making of fine china as the silver and pewter tankards were not suitable for that beverage. The public today wants cheapness, variety, and quality. In cheapness, low production costs are the great factor, hence the mechanical methods employed, but if more thought were given to the matter, cheap mass production could still have good shapes and pleasant colors. Variety of shapes is demanded but tastes appear to be crystallizing toward simplicity of design but brighter color. As to quality, the best one can afford is always the cheapest in the long run. A discussion is included. H.E.S.

Resistance of overglaze colors. G. B. *Verre & Silicates Ind.*, **6** [24] 431 (1935).—A series of tests on the resistance of colors to chemical agents and wear is given.

M.V.C.

Robertson, painter of Derby china. WILLIAM H. TAPP. *Connoisseur*, **96** [410] 193–97 (1935).—George Robertson came to Derby in 1795 to do the landscape decoration of the finer services and the occasional marine and animal subjects. It is difficult to verify the work of special artists in this line, but it is the opinion of the writer that once a particular pattern was assigned to an artist it remained his exclusively during his stay at the factory. Illustrated.

E.B.H.

Robineau, a significant American. ANON. *Design*, **37** [6] 20–22, 41 (1935).—Adelaide Alsop Robineau, best known in art circles for her unexcelled work in porcelains, had her greatest influence on the decorative arts of America through editing for 30 years the *Keramic Studio*, helping amateur, student, and teacher. A résumé of MRS. Robineau's work and ideals is given. E.B.H.

Roscoe collection of English glass. W. A. THORPE. *Connoisseur*, **96** [410] 205–209 (1935).—The collection of William Malin Roscoe was gathered from the "field" between 1894 and 1915. The descriptions and illustrations signify the wide range of the collector's taste. E.B.H.

Staffordshire figures in America. ALBERT LEE. *Connoisseur*, **96** [411] 262–65 (1935).—In the early 19th Century, Staffordshire potters, Adams, Clews, Wood, and others, shipped tons of tableware known now as Old Blue to America. Toward the middle of the century, pink, brown, mulberry, etc., were produced but these today are

in less favor than the blue. Not many figures were exported. In the early Victorian era American travellers brought these figures from England. Later they were put out for quantity rather than quality and the authenticity is often dubious. Still many Victorian figure makers maintained early traditions. Figures include national heroes, characters from Uncle Tom's Cabin, etc. As late as 1919 a Toby jug with a portrait of President Wilson was put out. Illustrated. E.B.H.

Steuben glass. C. LOUISE AVERY. *Bull. Met. Mus. Art*, **30** [10] 192–94 (1935); reprinted in *Design*, **37** [6] 30–31 (1935).—The Museum has a collection of modern decorative arts. Examples of modern French, Swedish, Viennese glass, and modern Italian glass from the Cappellin factory are included. Four excellent pieces of Steuben glass designed by Sidney Waugh have been added. One of these is a large, shallow, brilliant crystal bowl with the signs of the zodiac around the margins. A massive crystal bowl with a four-part support has a frieze pattern of gazelles. Another piece is a large crystal vase, architectural in character, of such transparency that the detail shows through from one side to the other, causing many reflections. A.A.A.

Steuben glass. ANON. *Studio* [London], **109** [505] 206–209 (1935).—This is an illustrated review of an exhibition of American glassware held in London. G.H.A.

Story of the lamp. F. W. ROBINS. *Discovery*, **16**, 332–34 (Nov., 1935).—Photographs of primitive pottery lamps are shown. H.H.S.

Tomb of Nefer-Khewet and his family. WILLIAM C. HAYES. *Bull. Met. Mus. Art.* [Egyptian Expedition Section, II], **30** [11] 23 (1935).—Vases and bowls of faience, some beautifully decorated, were found in this tomb. There are some fine jars covered with a highly burnished red slip and examples of smooth buff or pink ware with black line decoration. A.A.A.

Vancouver School of Art. ANON. *Studio* [London], **109** [507] 330 (1935).—Pottery forms an important section of this school's curriculum. G.H.A.

BOOK

D. Wolff and the Glasses That He Engraved. WILFRED BUCKLEY. Supp. Note by FRANS GREENWOOD. 41 pp. 25 plates. Methuen & Co., London, 1935. Price 25s. Reviewed in *Jour. Soc. Glass Tech.*, **19** [74] A234 (1935).—Before the publication of this monograph practically nothing was known about D. Wolff, except that he had engraved and signed nine glass goblets. By the skilful pursuit of slender clues, B. has identified him as David Wolff, baptized at s'-Hertogenbosch in 1732, and has established particulars of his parentage, marriages, and his death in 1798. Much searching of registers was necessary, in which B. acknowledges the help of the keepers of the Municipal Archives of s'-Hertogenbosch, The Hague, and Utrecht. The identification was confirmed by a graphological expert, who by close reasoning established that the signatures on four of the glasses, and that of "David Wolff" appearing on a document, were by the same hand. B. distinguishes three groups of glasses as follows: (*a*) twelve glasses which he definitely assigns to David Wolff, period of decoration about 1784–1796; (*b*) glasses engraved at an earlier period by various artists, many of them probably by David Wolff; (*c*) glasses engraved about 1775–1785 by some artist other than David Wolff. These findings are based on an illuminating and instructive analysis of the different methods of using the engraving tools, choice of subject, and draftsmanship. The work is an admirable example of scholarship, industry, and research, and of clear presentation. The numerous photographic illustrations, beautifully executed, form an important part of the book and are essential to the reader's appreciation of the argument.

PATENTS

Decalcomania. J. F. MCNUTT (American Decal Corp.). U. S. 19,839, Jan. 28, 1936 (Nov. 12, 1935); reissue of original U. S. 1,996,549, April 2, 1935.

Designs for:

Ash tray. R. G. COWAN (Onondaga Pottery Co.). U. S. 98,238, Jan. 21, 1936 (Oct. 7, 1935).

Bottle. M. R. DE MASCOLO (Soc. Anon. Scherick), U. S. 98,455, Feb. 4, 1936 (July 19, 1935). W. R. LEACH (Carr-Lowrey Glass Co.). U. S. 98,531, Feb. 11, 1936 (Dec. 19, 1935). W. H. MILLER (Carr-Lowrey Glass Co.). U. S. 98,459, Feb. 4, 1936 (Dec. 19, 1935).

Bowl. J. B. CLARK (Indiana Glass Co.). U. S. 98,453, Feb. 4, 1936 (Nov. 21, 1935).

Drinking tumbler. DONALD DESKEY (Libbey Glass Mfg. Co.). U. S. 98,420, Feb. 4, 1936 (Aug. 19, 1935).

Glass. J. B. CLARK (Indiana Glass Co.). U. S. 98,293, Jan. 28, 1936 (Oct. 5, 1935).

Goblet. A. J. BENNETT, U. S. 98,490, Feb. 11, 1936 (Dec. 7, 1935). J. B. CLARK (Indiana Glass Co.). U. S. 98,236, Jan. 21, 1936 (Oct. 16, 1935). W. C. MCCARTNEY. U. S. 98,539, Feb. 11, 1936 (Dec. 16, 1935).

Plate. YUKIO BUMA (Morimura Bros., Inc.). U. S. 98,211 to 98,225, Jan. 21, 1936 (Oct. 16, 1935) and U. S. 98,226, Jan. 21, 1936 (Oct. 21, 1935). H. F. WOOD, JR. (Continental Ceramics Corp.). U. S. 98,561 and 98,562, Feb. 11, 1936 (May 4, 1935).

Sherbet glass. DONALD DESKEY (Libbey Glass Mfg. Co.). U. S. 98,422, Feb. 4, 1936 (Dec. 14, 1935).

Treatment tub. C. R. CLARKE. U. S. 98,497, Feb. 11, 1936 (Nov. 9, 1935).

Tumbler. DONALD DESKEY (Libbey Glass Mfg. Co.). U. S. 98,421, Feb. 4, 1936 (Dec. 14, 1935).

Washstand. J. A. CALLAHAN (Briggs Mfg. Co.). U. S. 98,227 and 98,228, Jan. 21, 1936 (April 26, 1935).

Cements

Aluminous cements for work at high altitudes. ANON. *Génie Civil*, **107** [23] 543–44 (1935).—The temperature at high altitudes varies widely and almost daily drops to freezing. Aluminous cements set fast and are but little affected by low temperature so that their use for this work can be recommended. Several constructions on high mountains are described. J.D.G.

Boulder Dam. G. R. ROBERTSON. *Ind. Eng. Chem.*, **27** [3] 242–49 (1935).—The concrete block of Boulder Dam is so huge that serious overheating would have occurred deep

within its mass if only common Portland cement had been used as a binder in its construction. By reduction of the aluminate and increase of silicate in the cement, the production of chemical heat, particularly at early dates, was sharply reduced. Such items as grouted contraction cracks, refrigeration, particle size, and control of aggregate size have featured the studies leading to the final production of secure monolithic block. Illustrated. F.G.H.

Corrosion of cement: I, Portland cement and water. E. B. R. PRIDEAUX AND B. G. LIMMER. *Jour. Soc. Chem. Ind.*, **54** [42] 348–54 (1935).—Conductivities and hydrogen-ion concentrations (as p_H by H electrode) were used to determine the concentrations of calcium hydroxide dissolved from the pure solid as a standard. The solubility of pure lime obtained by these methods and potentiometric titration was found to be in good agreement with results of previous workers. The conductivity method, thus standardized, was found to be the more delicate in following slight changes of concentration. These methods were then applied to an investigation of the corrosion of Portland cement by pure water, since the presence of aluminates and calcium sulfate dissolved from the cement had relatively slight effects. Cylinders of neat cement were extracted with water under various conditions and figures were obtained for the amounts of lime removed per unit surface of cement and volume of solution. For the same times, these amounts increase with increase in the ratios of surface of cement to volume of solution. The initial effect of an inert aggregate on the rate of corrosion was negligible but in the later stages this rate was lower for a concrete than a neat cement. Rates of removal of lime and concentration of extract were compared in the case of pats and powders, respectively. About a quarter of the weight of powdered cement was removed by successive extractions with water. The most important factor governing the percentage dissolved is the ratio of volume of water to surface of cement. The rate of corrosion of massive pieces in the early stages resembles the rate of dissolution of a pure substance, but in the later stages it appears to be determined more by the rate of diffusion of lime through the surface of the solid. A typical hard water was found to remove more lime than pure water under the same conditions, and the (sulfate) hardness of the water was thereby reduced. G.R.S.

Lutes and cements. D. H. KILLEFFER. *Ind. Eng. Chem., News Ed.*, **12** [19] 355–56 (1934).—The composition, method of application, and field of service of approximately forty cements are reported under the following classifications: (1) silicate cements, (2) glycerol-litharge cements, and (3) miscellaneous cements. F.G.H.

Mold making. A. HEATH. *Pottery & Glass Rec.*, **17** [12] 317 (1935).—A plea for more research on plaster for molds is made and a method of mold-making used in Staffordshire, England, is described. Adequate blending of plaster and water is essential. A.B.S.

Permeability of mortars and concretes to petroleum products and new investigations on water-repelling substances. EDMOND MARCOTTE. *Génie Civil*, **107** [24] 563–66; [25] 585–87; [26] 614–16 (1935).—Several experiments are described on the speed of penetration of petroleum products through concrete, either protected or unprotected with outside coatings, and on the resistance to water penetration of concretes to the aggregate of which different water-repelling substances were added. The results were not concordant, being dependent on the proportion of the components used, storage of samples, time allowed for hardening, and pressure under which the liquids are applied. J.D.G.

Special Portland cements: IV, Chemical resistance of mangan chrome Portland cement prepared from natural raw materials. K. AKIYAMA. *Jour. Soc. Chem. Ind. Japan*, **38** [12] 747–50B (1935).—These cements do not differ from those prepared from pure chemicals in their chemical resistance to dilute sulfuric acid, and cements containing 1 to 2% chromic oxide and manganic oxide show the highest chemical resistance and hydraulic properties. For Part III see *Ceram. Abs.*, **15** [3] 83 (1936). M.V.C.

PATENTS

Arsenate cement or cement mixture. J. B. STÅLHANE (Bolidens Gruvaktiebolag). U. S. 2,028,420, Jan. 21, 1936 (Feb. 25, 1935). A cement mixture contains a calcium arsenate with a composition corresponding to one of the following: meta-arsenate ($CaO{\cdot}As_2O_5$) or pyroarsenate ($2CaO{\cdot}As_2O_5$), together with one of the following: lime, calcium silicate, Portland cement, aluminate cement.

High silica cement. F. A. B. FINKELDEY. U. S. 2,028,386, Jan. 21, 1936 (Jan. 24, 1934). Improvements in the manufacture of cement comprise mixing additional siliceous and calcareous materials with hot cement clinker as it comes from the clinkering kiln at a temperature ranging from about 700° to about 1050°C, and maintained in contact therewith for a time period to effect calcination of the calcareous material, the proportion of the added siliceous material being such as to equal up to about 24% of the combined materials when finished, and the calcareous material to yield an additional CaO content up to about 6% of the combined finished materials.

Manufacture of cement. C. H. BREERWOOD (Valley Forge Cement Co.). U. S. 2,028,313, Jan. 21, 1936 (July 24, 1934). The method of treating lime-bearing cement raw materials containing an undesirable quantity of at least one constituent, and in which the calcium carbonate value varies from time to time as received for treatment, comprises separating from each material the sands from the fine particles, separating an additional quantity of the coarser particles from the fines and combining them with the sands, subjecting the combined coarse particles to froth flotation, conducting the flotation operation so that the concentrate is maintained substantially at a desired calcium carbonate value and the rejects include the undesirable quantity of the constituent, combining the concentrate from the flotation operation with the untreated fines, the relative quantity of the part of each material so treated being such that the combination of the concentrate with the untreated fines will provide a mixture of the desired calcium carbonate value, and maintaining this value substantially constant continuously by varying the quantity of the coarser particles separated from the fines and added to the sands, whereby the combined quantity is varied inversely as the calcium carbonate value of the materials varies in the materials received.

Method of making a hard-surfaced cement. A. L. SMYLY. U. S. 2,028,956, Jan. 28, 1936 (Nov. 12, 1932).

Enamel

Accounting for porcelain enameled products: VI. CHARLES S. PEARCE. *Enamelist*, **13** [4] 24–25 (1936).—It has been standard practice for accountants to use the round figure of ten years for the depreciation and obsolescence of all heavy machinery and equipment. A thorough study of the latest developments in furnace design should be made to determine whether this figure or a shorter period should be used to amortize the cost. The usable life of equipment is not always the economical period of use for it. For Parts IV-V see *Ceram. Abs.*, **15** [3] 83 (1936). E.J.V.

Cleaning surfaces for enameling. M. PECRIAUX. *Verre & Silicates Ind.*, **6** [24] 428 (1935).—The preparation of surfaces for enameling and the beneficial effect of oil introduced in a sulfuric acid and a hydrochloric acid bath are discussed. M.V.C.

Color oxides for enamels. MAX PAQUET. *Emaillerie*, **3** [8] 7–13 (1935).—A survey of brown, reddish and yellowish brown, and ocherous coloring formulas is set forth. The methods of fabrication and examples in practical use are given. See also *Ceram. Abs.*, **15** [1] 8 (1936). M.D.

Development of the continuous vitreous enameling furnace. W. MARSHALL. *Sheet Metal Ind.* [London], **9** [104] 774–76 (1935).—A brief history of the development of enameling furnaces from the original box type to the present-day continuous furnace is given. The improved U-type furnace is claimed to (1) improve the quality of the ware, (2) decrease scrap, (3) lower manufacturing costs and increase production, and (4) be adaptable to any shop lay-out without excessive use of floor space. G.H.A.

Electric cooker and fire factory. ANON. *Sheet Metal Ind.* [London], **9** [103] 701–703 (1935).—A description of the works, including the enameling plant, of Messrs. Belling & Co. Ltd., Enfield, London, is given. Illustrated. G.H.A.

Enameling furnaces in central Europe. FRANZ STIASNY. *Enamelist*, **13** [4] 19 (1936).—The few continuous porcelain enameling furnaces used are chiefly heated with generator gas or fuel oil. Most of the plants producing a variety of articles use box-type furnaces heated with coal, coke, generator gas, light gas, fuel oil, or electricity. Heating materials are selected according to the condition of the country. See also "Porcelain enameling—" *Ceram. Abs.*, **15** [3] 85 (1936). E.J.V.

Enameling gray cast iron. ANON. *Giessereipraxis*, **56**, 277–79 (July 7, 1935); *Met. Abs.*, **6** [11] 440 (1935).—The following points of importance in manufacturing gray cast Fe for enameled products are stressed: (1) surface cleanliness of casting; (2) proper composition of molds; the S content of the powdered coal used should be as low as possible and not surpass 1 to 1.2%, since powdered coal with an S content of 2 to 2.2% considerably decreases the output of sound parts; (3) proper composition of Fe used, a metal containing about 2.8% Si, 0.6% Mn, 0.7 to 0.8% P, and 0.07 to 0.08% S being most suitable; the metal should be superheated and desulfurized; and (4) proper cleaning of casting.

Granite enamel for cast iron. L. VIELHABER. *Emaillerie*, **3** [8] 15–17 (1935).—Durability of enameling is related to thinness of coating. A very thin layer of sheet-steel ground-coat enamel may be used on cast iron. This enamel should contain no opacifier and should be rich in borax. A smooth, transparent coating will result, showing the gray color of the base metal; the high borax content causes the iron to dissolve and the enamel to be firmly anchored onto its support. The colored cover coat should be sprayed on. M.D.

Heat conductivity of pure iron and commercial steel. F. BOLLENRATH AND W. BUNGARDT. *Arch. Eisenhüttenwesen*, **9**, 253–62 (1935).—A review of recent work concerning the heat conductivity of practically pure iron and various steels is presented. Values were obtained at various temperatures. W.M.C.

History of iron and steel manufacture and its development in India. B. YANESKE. *Indian Engr.*, **90** [11] 245; [12] 262; [13] 285; [14] 302; [15] 322 (1931). A.P.S.

Improvements in vitreous enameling. B. T. SWEELY. *Metal Cleaning & Finishing*, **8** [1] 37–39 (1936).—The use of super-opaque frits has made possible the application of a thinner coat of enamel with greater covering power and less tendency to chip. Modern control methods have likewise resulted in better ware with reduced rejects. Instruments for measuring enamel properties are described. Developments in decorative enamel finishes are discussed. E.J.V.

Influence of time on creep of steels. A. E. WHITE, C. L. CLARK, AND R. L. WILSON. *Combustion*, **7** [2] 25–29 (1935).—Extended-time creep tests conducted at 1000°F on plain carbon steel and chromium-silicon-molybdenum steel indicate that in two cases considered, the 500-hr. test is a more conservative criterion than the 1000-hr. test. The assumption ordinarily made that a creep rate of 0.10%/1000 hr. represents a creep rate of 1.0%/10,000 hr. is open to question, at least for some steels. For the plain carbon steel this hypothesis may be approximately true, but for the chromium-silicon-molybdenum steel this relationship was not found. In fact, the stress giving this creep rate at the end of 1000 hr. produces, after 5000 hr., a creep rate of 1.0%/1000 hr. H.E.S.

Institute of Vitreous Enamellers. ANON. *Sheet Metal Ind.* [London], **9** [103] 671–77 (1935).—A full report is given of the second annual conference held in London in September, 1935. C. P. Stone's paper ("Common defects—" *Ceram. Abs.*, **15** [1] 8 (1936)) was discussed, the following points being raised: (1) effect of drying on enamel scrapings, (2) rôle of borax treatment in pickling, (3) C.R.C.A. steel versus ingot iron, (4) acid-proof enamels, and (5) design of castings. See also *Ceram. Abs.*, **14** [8] 183 (1935). G.H.A.

Method and apparatus for studying physical properties of vitreous enamels on steel. J. E. ROSENBERG AND A. LANGERMAN. *Jour. Amer. Ceram. Soc.*, **19** [3] 86–90 (1936).

Methods of minimizing distortion in light-gage steel. J. H. BLAHA. *Welding Jour.* [New York], **14** [11] 18–22 (1935).—In the manufacture of food liners for electrical refrigerators, the unit is built up from formed 20- to 22-gage sheet steel which is porcelain enameled after fabrication and welding by gas flame. A C content of 0.02 to 0.04 maximum is required for sheet for good enamel sur-

face, and the welding rod is of the same material in 1/8-in. strips clipped from sheet material. Distortion due to welding butted corners is prevented. Jigs completely support the sheet, top and bottom, and rigidly clamp all metal adjacent to the weld. Closely fitting cast-iron blocks are used for the jigs which are sometimes water-cooled. Retraining welders is necessary in order to turn out a satisfactory sheet-metal weld since welders experienced in heavy section welding must change their technic entirely to prevent burning or distorting the metal. In the discussion of porcelain firing the implication is that with the best care in butt welding the food liner, it may be finally rejected due to thermal shock of the porcelain and steel when the firing is done in a box-type furnace; in a continuous-type furnace the same care is given the liner as in welding. Photographs and diagrams are shown illustrating the type of weld made and the jigs for producing distortionless welds. W.H.B.

Porcelain enameling industry in Scandinavia. J. Swanstrom. *Enamelist*, **13** [4] 17–18 (1936).—The porcelain enameling industry in Scandinavia, which includes Denmark, Sweden, and Norway, is very old, but the factories have progressed technically and are quite modern. Products vary to fit differing conditions in the three countries. In Denmark the ware is produced for use with gas as the chief fuel. In Sweden electrical ranges and cooking apparatus are used entirely. The furnaces used in the plants include coal-heated muffles, oil-heated, and electric muffle-type ovens. E.J.V.

PATENTS

Balanced sink structure. R. L. Ottke (Standard Sanitary Mfg. Co.). U. S. 2,028,803, Jan. 28, 1936 (Dec. 6, 1934).

Cleaning and pickling of metal articles. C. Arnold (Ferro Enamel Corp.). Brit. 440,564, Jan. 15, 1936 (June 28, 1934).

Sink structure. R. L. Ottke (Standard Sanitary Mfg. Co.). U. S. 2,028,802, Jan. 28, 1936 (Dec. 6, 1934).

Glass

Adsorption of pigments on glass. J. Lenoir. *Document. Sci.*, **4** [4] 193–99 (1935); abstracted in *Chem. Zentr.*, ii, 2933 (1935).—Glass wool or glass powder is used for adsorption tests with pigment solution. The amount of the adsorbed pigment is determined colorimetrically. The amount of adsorbed material increases sharply with very dilute solutions. The adsorption isotherm shows a sharply increasing curve; the maximum is reached soon and the isotherm changes into a straight line with relatively low concentrations. They follow the exponential equation of Freundlich. The calculation of the thickness of the adsorbed methyl violet layer showed a coating of dimolecular thickness. M.V.C.

Chemical cleaning of molds. Anon. *Glass Ind.*, **17** [2] 47–48 (1936).—The electrolytic cleaning method, involving the use of a high conductivity alkaline solution, is effective and takes less time. Scale is cleaned off by pickling in an acid bath following removal of the oil and grease. An inhibitor which decreases the rate of attack of the acid on the metal but does not retard the action of the acid on the scale is used in the pickling bath. E.J.V.

Classification of optical glasses. Renato Moretti. *Centro Studi Ceram.*, **2** [6–7–8] 74–77 (1935).—The different kinds of crown and flint glasses are described and classified. M.V.C.

Conception of a complex viscosity and its application to dielectrics. A. Germant. *Trans. Faraday Soc.*, **31** [11] 1582–90 (1935).—To explain the observed decrease with increasing frequency of the apparent viscosity in cases concerned with molecular vibrations in amorphous solids, the conception of a complex viscosity, V, is introduced instead of the simple real value (η). The Maxwellian theory which proved so useful in explaining the macroscopic behavior of plastic bodies is here applied to molecular vibrations. By this means account is taken both of the viscous and of the elastic displacements of the molecules. It is applicable to materials in any state of transition between liquid and crystal (generally referred to as the amorphous or vitreous state). A special application of the theory to dielectric losses due to dipole rotation is given and it is found that the results are qualitatively in accord with observations on glass and paraffin. Losses are extended over a wide frequency range, and peaks may occur at two different characteristic frequencies, corresponding to the static viscosity and the damping of elastic vibrations. Often only the second one is detectable, yielding for this frequency range a much lower value of apparent viscosity than the static value. G.R.S.

Course in glassmaking. Anon. *Verre & Silicates Ind.*, **6** [24] 429–31 (1935).—Tests on fuels are outlined. See also *Ceram. Abs.*, **15** [1] 13 (1936). M.V.C.

Czechoslovakian laboratory glass is compared with German Jena glass. L. A. Helwich. *Ind. Eng. Chem., News Ed.*, **12** [22] 410 (1934); for abstract see *Ceram. Abs.*, **14** [5] 110 (1935). F.G.H.

Effect of temperature and salt additions on the viscosity of borosilicate glass. P. E. Frank and O. N. Spiridonova. *Jour. Opt. Mech. Ind.* [U.S.S.R.], **9**, 6 (1934); *Jour. Soc. Glass Tech.*, **19** [74] A219 (1935).—The glass investigated was of Pyrex-brand composition, namely, SiO_2 80.40%, B_2O_3 11.99, Na_2O 5.11, As_2O_3 0.50, Al_2O_3 1.49, and MgO 0.51. The following salts were introduced into the batch: $UO_2(NO_3)_2 6H_2O$, $Th(NO_3)_4 12H_2O$, (NH_4OH)-$H_2O 7MoO_3$, $BeCO_3$, $Ce(CO)_2 5H_2O$, and Na_2SiF_6. These salts were added in quantities of 0.5 and 1.5%, so as to form the oxides UO_3, ThO_2, MoO_3, BeO, and CeO_2. Melting was carried out in Alundum crucibles. The viscosities were determined over a range 30 to 10,000 dyne/sec./cm.^{2} by means of a torsional balance of special design, a platinum ball on a platinum rod being immersed in the melt. The possible error in the viscosity determinations did not exceed 5%. With Pyrex-brand glass having a viscosity of 275 units at 1475° the addition of 1.5% UO_3 increased the viscosity to 2375 units, 0.5% MoO_3 to 1270, 0.5% BeO to 1210, 0.5% CeO_2 to 1345. At 1400° the addition of 0.5% Na_2SiF_6 increased the viscosity of the glass by 645 units and 1.5% of the same compound by 540 units. At 1400°, 0.5% UO_3 or CeO_2 altered but little the viscosity of

Pyrex-brand glass; with 0.5% ThO_2 and 0.5% BeO at the same temperature the viscosity was increased by 510 and 540 units, respectively. The temperature-viscosity coefficient varied with the temperature and with different additions at the same temperature.

Experiment on theoretical research of the conductivity of glasses. R. L. Müller. *Acta Physicochim. U.S.S.R.*, **2** [1] 103–25 (1935). S.I.P.

Formation of sulfate liquor in soda glass. I. I. Kitaigorodskiĭ and Ya. A. Shkolnikov. *Sprechsaal*, **68** [36] 556–58; [37] 572–74 (1935); see "Glass Technic," *Ceram. Abs.*, **14** [1] 12 (1935). M.V.C.

Glass insulators. Rudolf Hohlbaum. *Glashütte*, **65** [39] 609–10 (1935).—Glass insulators for low tension are used in Poland, Roumania, Italy, and France. A soda calcareous semi-white glass approaching the trisilicate formula is used. Details are given. M.V.C.

Glass sand driers. F. Jochim. *Glastech. Ber.*, **13** [11] 391–99 (1935).—Sand drying is treated from the technical viewpoint. J. describes the usual driers in glass plants and gives a summary of methods of heating the driers and the most useful types of drier buildings. A report on factory processes with a tunnel drier and a summary on the economic study of sand driers are included. G.R.S.

Glass thread 40,000 miles long from one pound of ordinary glass. Anon. *Esso Oil-Ways*, **2** [7] 1–3 (1936).—The history of the Owens-Illinois Glass Co. is traced from the invention by Michael Owens in 1903 of a machine for producing glass containers to the recent development of a machine making glass thread one-twentieth the diameter of a human hair. Mold lubricants used in bottle-making machines are discussed. Illustrated. H.S.

Glass wool in the synthetic materials industry. F. Ohl. *Plast. Massen Wiss. Tech.*, **5**, 108–12 (1935); abstracted in *Chem. Zentr.*, **ii**, 263 (1935). M.V.C.

Glassworking in Sweden. Edw. Strömberg. *Tek. Tid.*, **65**, 151–58 (1935); abstracted in *Chem. Zentr.*, **ii**, 1077 (1935).—A review is given. M.V.C.

Influence of melting time on the iron oxide content of glasses. Franz Bauer. Translated in *Glass Ind.*, **17** [2] 41 (1936); for abstract see *Ceram. Abs.*, **15** [1] 13 (1936). E.J.V.

Keeping safety glass safe. Anon. *Glass Ind.*, **17** [2] 61 (1936).—The Underwriters Laboratories in Chicago conduct tests on bullet-resistant glass and fire windows to determine their adherence to the claims made for them. Illustrated. E.J.V.

Magnitude of the surface of powdered glass. E. Berger, W. Geffcken, and K. V. Stosser. *Glastech. Ber.*, **13** [9] 301–25 (1935).—The designation of the surface of glass grains by certain statistical values resulted from theoretical considerations and experimental studies. These values are easily reproducible provided precautions are taken in the preparation of the samples. It is to be observed that for practical purposes the effective surfaces and not the absolute are thus obtained. The values will, in general, not agree, as shown by measurements of the solution in nitric acid and adsorption of iodoesin. 23 references. G.R.S.

Methods of measuring visible and total energy transmissions of heat-absorbing glasses. H. P. Gage. *Trans. Illuminating Eng. Soc.*, **30**, 411–27 (1935); *Jour. Soc. Glass Tech.*, **19** [75] A311 (1935); for abstract see *Ceram. Abs.*, **14** [2] 35 (1935).

Modern large telescope design. F. G. Pease. *Jour. Opt. Soc. Amer.*, **25**, 156–61 (1935); *Jour. Soc. Glass Tech.*, **19** [75] A316 (1935).

Nature of the electrical conductivity of low-alkali borate glasses. R. Müller and B. Markin. *Acta Physicochim. U.S.S.R.*, **1** [1] 160–67 (1934). S.I.P.

Old English glass: No. 62, Barometers. Francis Buckley. *Glass*, **12** [8] 344 (1935).—A description of the various types of glass barometers made and used in England from 1700 to 1750 is given. **No. 63, Making optical glasses.** *Ibid.*, [9] 388.—B. discusses 17th Century methods of grinding and polishing optical glass and watch glasses. For No. 61 see *Ceram. Abs.*, **14** [10] 238 (1935). M.C.S.

Opal glass: I, Silicon, calcium, sodium, oxygen, and fluorine series. H. H. Blau, Alexander Silverman, and Victor Hicks. *Trans. IX Internat. Congr. Pure and Appl. Chem.* [Madrid, Spain], Vol. **3** (1934). **II. Silicon, calcium, sodium, aluminum, oxygen, and fluorine series.** *Jour. Amer. Ceram. Soc.*, **19** [3] 63–66 (1936).

Quality under the thumb. J. Gavin Callinan. *Factory Management & Maintenance*, **93** [12] 509, ad. pp. 46–48 (1935).—The system of inspection in use in the plant of a flat-glass factory employing the Fourcault process is described. An inspector has only to pick up a speaking tube or switch on one of a series of signal lights to tell a machine operator in another part of the factory of a certain defect or trouble. The light is not extinguished until the operator has remedied the trouble. Illustrated. J.L.G.

Research of thermal expansion of binary systems Na_2O-$B_4O_7B_2O_3$ in fused state. M. P. Volarovich. *Acta Physicochim. U.S.S.R.*, **2** [6] 695–710 (1935).—A method is established for determining the specific volume of fused substances at high temperatures up to 1300°C. The method is based on the principle of the dilatometer. See also "Investigation—" *Ceram. Abs.*, **13** [5] 112 (1934). S.I.P.

Results obtained in the safety-glass industry. Fritz Ohl. *Plast. Massen Wiss. Tech.*, **5**, 203–205, 228–35 (1935); abstracted in *Chem. Zentr.*, **ii**, 3279 (1935). M.V.C.

Safety glasses with a celluloid intermediate layer. Fritz Ohl. *Nitrocellulose*, **6**, 120–23 (1935); abstracted in *Chem. Zentr.*, **ii**, 3279 (1935). M.V.C.

Sandwich glass. Alexander Silverman. *Glass Ind.*, **17** [2] 50–56 (1936).—A brief historical sketch is given of the production of crystal glass at the Boston & Sandwich Glass Co. plant started at Sandwich, Mass., in 1825. This plant was the first to use gas (coal gas) in the furnace and coke in the leers. In treating crystal glass the designs were obtained through patterns in the molds and through cutting and engraving; hydrofluoric acid was used for etching. The putty method was used for polishing. The crystal glass batches recorded by William E. Kern and George L. Fessenden, two former employees of the factory, are given as copied from the originals. Illustrated. E.J.V.

Selenium-pink color. W. Hofler and A. Dietzel. Translated in *Glass Ind.*, **17** [2] 49 (1936); for abstract see *Ceram. Abs.*, **14** [2] 36 (1935). E.J.V.

Silvering of glass. Traute Liepus. *Glastech. Ber.*, **13**

[8] 270–78 (1935).—When a silvered glass is heated to about 250°C, a crystallization is started which depends on the migration of the silver molecules on the surface of the glass. At about 600°C the silver diffuses into the glass with the formation of a yellow tint. This process is independent of the composition of the glass. The intensity of the color is dependent on the composition, temperature, length of time of heating, and the density of the silver layer. The presence of oxygen is essential to the process of silver crystal growth on heating. From about 600° to 900° the silver diffuses into the glass and is dissolved in it, the silver ion replacing the alkali ions. The yellow color obtained in this way is the result of true solution of silver in the glass. The glasses containing silver show a higher conductivity than glasses without silver.

G.R.S.

Sound recording on glass. V. G. Manufacturing Co. *Elec. Rev.*, **117** [3031] 895–96 (1935).—A sapphire or steel needle is used to cut the sound impression into a non-inflammable composition coated on the glass disk, a "Simplat" record. If the record is required to play more than twelve times it is given a simple hardening and polishing process which gives it a life of 150 runs. The cut groove is clearer and smoother than that of the ordinary record. Since glass has scarcely any audible resonance of its own a wide frequency range and great volume are possible without distortion and without background noise. The records are less fragile than those of the usual composition and are unaffected by climatic conditions. Illustrated. J.L.G.

Splinterless glass. Erich Boye. *Chem.-Ztg.*, **59**, 582–84 (1935); abstracted in *Chem. Zentr.*, **ii**, 2865 (1935).—Splinterless glass with (*a*) foils (cellulose ester) as the intermediate layer and (*b*) dissolved or plastic materials as the intermediate layer is discussed. M.V.C.

Technic of photochemical changes produced in glass by ultra-violet rays and their regeneration by heating. A. Klamm and E. Berger. *Glastech. Ber.*, **13** [10] 349–68 (1935).—Solarization and regeneration effect changes in permeability only in the short-wave region of the spectrum. For a given wave-length there is a linear variation of permeability with the log of time of exposure. Mathematical deductions lead to a single formula which is in practical agreement with experimental results on the changes in permeability with the time of exposure to each wave-length and to the regeneration temperature. The speed of regeneration is proportional to about the fourth power of the absolute temperature. The same formula also shows the course of the solarization, if it is assumed that the irradiation produces an energized state corresponding to a heating at about the transformation temperature. The energy thus absorbed will be freed by the regeneration in the form of a luminous phenomenon. 31 references.

G.R.S.

Temperature dependence of absorption of colored glasses. H. Lütge. *Russ.-deut. Nachr. Wiss. Tech.*, No. 8, pp. 44–46 (1934); abstracted in *Chem. Zentr.*, **ii**, 1762 (1935). M.V.C.

Temperature-viscosity relationships of some lead furnace slags. Kurd Endell, A. Tielsch, and C. Wens. *Metall & Erz*, **31** [16] 353–57 (1934).—The temperature-viscosity relations of lead slags as they depend on composition were studied. The conditions of crystallization on cooling of the slags were investigated. A simple ball viscometer is described with which viscosity measurements from 1 to 100,000 poises can be measured accurately at temperatures varying from 850° to 1450°C. The results of measurements on seven lead slags are reported. The viscosities of the slags varied from 1 to 3 poises between 1300° and 1400°C; the composition of the slags varied considerably. The viscosities of these slags are of the same magnitude as the viscosities of iron slags above 1400°C. At 1300°C the viscosities of lead slags (mean value, 3 poises) are to the viscosities of Mansfeld slags (mean value, 200 poises) as 1:70. At this temperature Mansfeld slags are therefore much more viscous.

L.T.B.

Testing multiple-layer safety glass for weathering resistance by the standard German method. E. Albrecht. *Glastech. Ber.*, **13** [8] 279–81 (1935).—A. discusses the measurement of radiant energy in order to determine the action of sunshine on the discoloration of the bond in safety glass. 5 references. G.R.S.

Transmission of solar radiation through heat-absorbing glass. R. S. Estey and R. A. Millar. *Trans. Illuminating Eng. Soc.*, **30**, 403–10 (1935); *Jour. Soc. Glass Tech.*, **19** [75] A313 (1935); for abstract see *Ceram. Abs.*, **14** [2] 36 (1935).

Ultra-violet transmission changes in glass as a function of the wave-length of the radiation stimulus. W. W. Coblentz and R. Stair. *Proc. Nat. Acad. Sci.*, **20** [12] 630–35 (1934).—A soda-lime-silica (Vitaglass AG-2A) glass and a soda-silica glass were exposed to spectroscopically isolated homogeneous, ultra-violet radiation from a quartz-mercury arc lamp. This changed the ultra-violet transparency of the glasses markedly. The changes in transmission start at 405 mμ and extend into the extreme ultra-violet where they are masked by the opacity characteristic of glasses containing silica. Observations to determine changes in transmission were made at a wave-length of 302 mμ. For wave-lengths shorter than 365 mμ, the shorter the wave-length the greater is the photochemical action in the direction of greater absorption. A potash-lime-silica glass was not materially affected in its ultra-violet transmission after exposure to the arc lamp. This indicates that the soda is the photosensitive constituent in a soda-lime-silica glass. A phosphate-lime glass (Corex A) was depreciated in ultra-violet transmission only by wave-lengths shorter than 290 mμ. No wave-lengths were found to increase its ultra-violet transmission. The data secured in the investigation are represented graphically. With the soda-lime-silica glass the shortest wave-lengths are most powerful in cutting down ultra-violet transmission while the longest wave-lengths are most powerful in building it up. J.L.G.

What is crystal glass? L. Springer. *Glastech. Ber.*, **13** [8] 265–70 (1935).—A demarcation of crystal glass from related kinds of glass is followed by a general classification of hollow glass or crystal glass. A narrower conception of the term "crystal glass" is traced on the basis of the historical development of the word "crystal," and the steps are followed in registration of ware for German tariff. A more accurate understanding of crystal glass is gained from the classification on the basis of composition into lead-free and lead-containing crystal, and the differentiation into

potash crystal and soda crystal or normal lead crystal and special crystal. Whole crystal contains 76.6 SiO_2, 6.4 CaO, 9.4 K_2O, and 7.6% Na_2O; half crystal, 78.0 SiO_2, 6.1 CaO, 3.7 K_2O, and 12.2% Na_2O; heavy lead crystal, 55.9 SiO_2, 32.7 PbO, 11.4% K_2O; and "normal" lead crystal, 65.7 SiO_2, 19.3 PbO, and 15.0% K_2O. G.R.S.

Works photoelectric method for the photometry of electric discharge lamps. P. D. OAKLEY. *Illuminating Engr.*, **28**, 181–85 (1935); *Jour. Soc. Glass Tech.*, **19** [75] A315 (1935).—The apparatus was required for the measurement of simple high-pressure mercury-vapor lamps and lamps having an addition of cadmium and zinc. These two types gave red transmissions through Wratten Filter No. 25 of approximately 1% and 2.0 to 2.5%, respectively. Lamps of each type were photometered visually by four observers having Y/B ratios 0.78, 0.93, 0.95, and 1.02, by the use of a calibrated filter, and values for normal Y/B = 1.0 were interpolated. The effect of the color of the paint of the 4-ft. diameter integrating sphere was also investigated. These lamps were then photometered photoelectrically, the ratio P.E. Value : Visual Value being 91.9% for uncorrected lamps and 104.1% for "corrected" lamps. Filters were inserted until these ratios were the same for both types of lamp. Using Wratten Filter No. 86 (yellow) the error introduced was less than 1.0%. The set-up was controlled by daily standards which were checked by lamps run only once a week, and these in turn were checked periodically by an aged standard lamp.

BOOKS

Glass Technology. A. A. GEZBURG. State Pub. House of Light Ind., Moscow, 1935. 152 pp. Price 2R 30k. This is a text book for plant schools. The first chapter is devoted to the manufacture of refractories for glassmelting furnaces. G.'s definition of sintering temperature is incorrect. The book contains nothing new dealing with the usual practice of glass technology. S. I. PERKAL

Modern Glass Practice. SAMUEL R. SCHOLES. Industrial Publications, Inc., Chicago, 1935. vi + 344 pp. 66 figs. and diagrams. Price $6.00. S. has planned this book as a text for students in glass technology, as a scientific reference work for operatives in glass factories, and as a source of information for the general reader. The book is divided into twenty-four chapters outlining the field of glass technology and glass practice. The "general reader," mentioned in the preface,will undoubtedly skip the quotation from Morey's excellent paper on phase equilibrium relationships and most of Preston's able, 22-pages summary of the mechanical properties of glass. The chapters contributed by Sharp, "Chemical Composition of Glass," and by Blau, "Colored and Opal Glass," because of the nature of the subjects discussed, should prove easier to digest. Approximately one-half of the volume is devoted to a discussion of the composition of glass and the principles of glassmaking. Fuels and furnaces are allotted thirty-eight pages. The latter half of the book covers mechanical glassworking and the physical properties of glass. Twelve pages on refractories conclude the volume.

Everyone interested in glass will want to add this volume to their library and it should be welcomed by all teachers of glass technology. It satisfies a need for an American text book in this field and it is a good general introduction to the subject.

A few minor errors have been noted. The bulb machine to which reference is made on page 186 was not designed by a man named "Westlake." Westlake is simply a name given to a certain type of bulb-blowing machine.

In connection with decorative processes (p. 234) it is stated that silvered astronomical mirrors can not be repolished, but Ellerman and Babcock, in "The Making of Reflecting Surfaces," Phys. Soc. [London] and Opt. Soc., Article No. 5, p. 16 (Nov., 1920), state that "The telescope mirrors at the Mount Wilson Observatory are resilvered once or twice a year. The mirrors used for solar work are burnished (repolished) once or twice a week. In some cases a mirror is more brilliant after several weeks' use than when new."

In discussing metal-to-glass seals (p. 264) S. says that the expansibility of metal and glass must be approximately the same. This is true when we consider the sealing of large gage wires in glass, but a special type of seal was devised by Housekeeper and is in use commercially for sealing copper (expansion 167×10^{-7}) directly to Pyrex-brand glass (expansion 32×10^{-7}).

In describing the interferometer method for measuring expansion (p. 296) S. refers to the roughening of the outside surfaces of the interferometer. The bottom surface of the lower interferometer plate is roughened, but the upper surface of the top plate is finished so that it is not parallel to the surfaces between which interference takes place. The reflection from this upper surface is thus thrown out of the field of view of the instrument. The interferometer is not illuminated with "light of short wavelength," and a monochromatic source (in the ordinary sense of the word) is not only "preferable," it is necessary if interference is to be established over a path difference of 1 cm.

It is stated also that "the extreme accuracy of measurement of the expansion itself is offset to some extent by the lack of relative accuracy possible in measuring the length of the small specimens." This statement is not true. By means of three wave-lengths the order of interference at the contact points of each of the three small specimens can be determined within ± 0.1 of a fringe width. If the specimens are approximately 5 mm. long we can determine their individual lengths within ± 0.00003 mm., a precision of 1 part in 100,000.

There is also an obvious misprint on page 335. The reference to the article by "Thompson and Craner, *J. Eng. Chem.*, 1933, p. 856," should read Thompson and Kraner, *Ind. Eng. Chem.*, **25**, 856–64 (1933).

C. D. SPENCER

Tank Furnace (Le Four à Bassin). R. W. DEVILLERS AND F. E. VAEREWYCK. Monograph No. 1 of "Studies of Siliceous Compounds" (Les Études des Composés Siliceaux). l'Electro Imprimerie, Brussels, 1935. 233 pp. 108 figs., 1 plate. This monograph is introduced by the Belgian Minister of Economic Affairs. There is also a preface by a member of the Fourcault organization. In the authors' preface, the object of the book is given as the presentation of familiar principles governing the construction and operation of tank furnaces. They recognize the empiricism that has prevailed in the industry and the rapid

developments of the present decade. The need for a more scientific approach to the study of tanks for glassmelting has encouraged them to undertake this work.

The book is divided into eighteen chapters, and the bibliographical references are grouped in two pages at the end of the text. Following this is an interesting technical lexicon of about two hundred terms in French, English, and German. The subject matter is logically divided, and the relative space given to each subdivision is well proportioned. The historical matter is exceedingly brief, presenting little more than the names of the men who first developed the various types of tanks and methods of firing. A few general statements are made in regard to pot and tank melting, and confidence is expressed in the continued supremacy of the tank as a melting unit for manufacturing glassware on a large scale and in the continued improvement in the quality of glass thus produced. In subsequent chapters, the various types of tanks are classified and there is a comparatively brief description of the materials of construction. Here the treatment is modern and scientific, and there is little attempt to describe manufacturing processes for blocks and brick. A description of the separate elements making up tanks follows in the longest chapter in the book. This chapter, like others, is illustrated by simple sectional drawings, which are diagrammatic rather than pictorial. There are no illustrations from photographs in the book. It must be remarked, however, that the drawings and diagrams are perfectly clear and easily understood.

Following some excellent engineering information on the calculation of dimensions, there is a chapter on fuels, which, while it offers nothing new, presents an excellent approach to the subject from the standpoint of comparative calorific values and such matters as cost and convenience. The practical matters of combustion and firing and of melting and refining the glass are well treated. One of the most interesting chapters is that relating to the currents resulting from convection in the glass tank.

The matter of heat balance receives ten pages. The gas producer is carefully analyzed for efficiency. The behavior of producer gas in the regenerators and the losses incident to the reversing operation are carefully examined. For the tank itself, the heat balance is calculated for a batch in which a quantity of sulfate quite unusual in American practice is employed. The upper temperature is taken at 1400°C, which would be unusually low in America. Average specific heat is estimated at 0.32, and the heat consumed in chemical reaction is placed, somewhat arbitrarily, at 272 cal./kg. An elaborate estimate of the various losses is tablulated, and a final estimate of efficiency is given at 12.8%. These details are cited as illustrative of the manner in which the authors have taken specific cases rather than general discussion in the development of the separate details of tank construction and operation.

The chapter on construction is well packed with exact information. It is interesting to note the close similarity between Belgian and American practice in the details of construction.

Attention is paid to the procedures necessary in heating up tanks and taking them out of fire. The chapter, "Operation of Tanks," covers methods of charging, distribution and control of temperature, and melting capacity and includes, strangely enough, three pages on explosions and their prevention. A scheme for automatic regulation is presented which offers far more instruments and gages than are usually found on American tanks. The various types of pyrometers, pressure and draft gages, flue analyzers, and hygrometric controls are presented by descriptions and diagrams.

The subject of waste-heat boilers, which is neglected with us because of the comparative cheapness of our fuels, receives a brief chapter. The authors finally conclude that the tank furnace remains a quite primitive thermal apparatus, with all its improvements. They point out that the need is all the greater for scientific study of its behavior and characteristics and of the consequent best possibilities of the apparatus.

The absence of an index is disappointing. The table of contents gives only the barest chapter headings. The printer's work is excellent. The style is typically French, extremely concise and logical throughout. It is possible that in the application of formulas and calculations, too much confidence has been placed in numbers which must vary widely, not only for different tanks but for the same tank as it remains in operation from day to day. On the whole, the book is an excellent contribution to the literature of glass and is worthy to take its place as a reference work beside those of Lamort and Dralle-Keppeler in German.

S. R. SCHOLES

Theory of Glass Formation and Methods of Glassmelting. I. I. KITAIGORODSKIĬ. State Pub. House of Light Ind., Moscow, 1935. 188 pp. Price 3R 40k. This book has nine sections dealing with the following subjects: (1) state of glassmaking in the past and present, (2) analysis of the work of modern glassmelting furnaces, (3) methods for improving the processes of glassmelting and increasing the coefficient of efficiency of the furnaces, (4) new ideas in construction of glassmelting furnaces, (5) theory of glass formation, (6) research works of the State Experimental Institute of Glass on accelerated methods of glassmelting, (7) models of furnaces for glassmelting in the suspended state, (8) theory of thin-layer melting of glass, and (9) practice of thin-layer melting of glass. K. has successfully summarized and generalized our knowledge of the most vital questions of glass technology in the light of the modern state of this problem and personal research works and critical notes on these subjects. This small, well-written book contains valuable data and original thoughts important both from the theoretical and practical standpoints and may be recommended for translation into English.

S. I. PERKAL

PATENTS

Adjustable pouring lip for discharging glass from tank furnace, e.g., for casting plate. SCHLESISCHE SPIEGELGLAS-MANUFACTUR C. TIELSCH G.M.B.H. Ger. 612,976, April 11, 1935 (March 8, 1932), VI/32*a*, Gp. 5; *Jour. Soc. Glass Tech.*, **19**[75] A287 (1935).—A refractory lip member is pivoted at its lower edge so that it can be swung outward and downward to discharge molten glass into a container while serving in its uppermost position as a retaining wall of the tank.

Apparatus for:

Drawing and severing glass tubing or rod. BRITISH

THOMSON-HOUSTON CO., LTD. Brit. 440,995, Jan. 22, 1936 (June 21, 1934).

Feeding molten glass into molds, etc. NEUE GLASINDUSTRIE-GES. Brit. 440,627, Jan. 15, 1936 (Aug. 6, 1934).

Laminating glass. WILLIAM OWEN (Pittsburgh Plate Glass Co.). U. S. 2,028,916, Jan. 28, 1936 (March 9, 1934).

Making laminated glass. EDLO DONNINI (American Window Glass Co.). U. S. 2,030,572, Feb. 11, 1936 (May 6, 1933). J. H. SHERTS (Duplate Corp.). U. S. 2,028,927, Jan. 28, 1936 (Feb. 17, 1934) and U. S. 2,028,928, Jan. 28, 1936 (April 28, 1934).

Tempering glass. COMPAGNIES RÉUNIES DES GLACES ET VERRES SPÉCIAUX DU NORD DE LA FRANCE. Brit. 440,467 and 440,556, Jan. 15, 1936 (April 9, 1934).

Bulb-spraying device. JOSEPH RUSSI (Hygrade Sylvania Corp.). U. S. 2,028,355, Jan. 21, 1936 (June 7, 1935).

Colored-glass transparencies. PILKINGTON BROS., LTD., AND V. W. JENNINGS. Brit. 440,459, Jan. 15, 1936 (Jan. 25, 1935).

Composite glass container. N. B. REYNOLDS (General Electric Co.). U. S. 2,030,397, Feb. 11, 1936 (Dec. 17, 1932). An electrical discharge device comprises a sealed container of fixed form constituted mainly of silicate glass, a charge of alkali metal therein, means for conducting electric current through the vapor of the metal, and an inner coating of glass of materially lower fusing temperature, resistant chemically to alkali vapor, and having a short working range and fused *in situ* to the formed container.

Continuous production of flashed glass. B. ENGELS. Ger. 607,438, Dec. 13, 1934 (Nov. 11, 1929); addition to Ger. 605,739, Nov. 17, 1934, 32*a*, E 95.30, Gp. 23_{01}; *Jour. Soc. Glass Tech.*, **19** [74] A195 (1935).—The draw pot for the base glass is surrounded by one containing the glass for flashing so that the latter is drawn from the inner edge of its container by the rising cylinder of base glass.

Controlling annealing of glassware. CORNING GLASS WORKS. Ger. 613,752, May 9, 1935 (Feb. 3, 1934), VI/32*a*, Gp. 30; *Jour. Soc. Glass Tech.*, **19** [75] A296 (1935).—Means are provided for absorbing the heat given out by some parts of the ware and reflecting back that given out by others.

Cutting continuously produced glass tubing while in motion. PATENT-TREUHAND-GES. FÜR ELEKTRISCHE GLÜHLAMPEN M.B.H. Ger. 612,175, March 28, 1935 (April 27, 1934), VI/32*a*, Gp. 33; *Jour. Soc. Glass Tech.*, **19** [75] A301 (1935).—A cooled and porous tool is used to sever the tube, moving with it while being drawn across it. The tube is lifted and returned to the starting point for the next cut.

Electric glassmelting furnace. PATENT-TREUHAND-GES. FÜR ELECTRISCHE GLÜHLAMPEN M.B.H. Ger. 613,050, April 18, 1935 (June 11, 1932), VI/32*a*, Gp. 4; *Jour. Soc. Glass Tech.*, **19** [75] A255 (1935).—In a furnace in which the glass itself serves as the resistor with metal electrodes embedded in the walls, the electrodes take the form of metallic boxes with their open ends facing outward.

Facilitating cracking-off operations. J. DICHTER. Ger. 608,087, Dec. 12, 1934 (Feb. 5, 1931), VI/32*a*, Gp. 27; *Jour. Soc. Glass Tech.*, **19** [74] A209 (1935).—A small ring-like depression is formed on the glass, *e.g.*, in ampoule making, etc., by the coöperation of an external necking tool and a plug-like supporting member located within the article.

Forming prismatic-shaped glassware. J. TITTEL. Ger. 608,086, Dec. 20, 1934 (March 22, 1932), VI/32*a*, Gp. 7; *Jour. Soc. Glass Tech.*, **19** [74] A162 (1935).

Furnace. C. A. BOWEN (Corning Glass Works.). U. S. 2,029,052, Jan. 28, 1936 (Nov. 10, 1933).

Glass. LOUIS NAVIAS (General Electric Co.). U. S. 2,030,390, Feb. 11, 1936 (Aug. 11, 1934).—In combination with an electrical discharge device which contains a quantity of chemically active material and comprising a container which is susceptible to chemical attack by the material, a lining for the container comprises a barium-containing borosilicate glass, the barium oxide content of which is within the limits of about 25 to 50%, the boric anhydride of which is within the limits of 50 to 20%, and the silica content of which is less than about 20%.

Glass-feeding shelf. A. F. TREMBLAY. U. S. 2,028,960, Jan. 28, 1936 (Aug. 23, 1934).

Glass-forming machine with multiple molds. HAIDEMÜHLER GLASHÜTTENWERKE G.M.B.H. Ger. 611,640, March 14, 1935 (March 17, 1929), VI/32*a*, Gp.13; *Jour. Soc. Glass Tech.*, **19** [75] A277 (1935).—The patent covers the use of multiple molds on Schiller-type machines, each mold charge being separately sheared into the mold orifice.

Glass gathering and forming machine. R. W. CANFIELD (Hartford-Empire Co.). U. S. 2,030,810, Feb. 11, 1936 (March 8, 1929).

Glass-working apparatus. H. R. SCHUTZ (Libbey Mfg. Co.). U. S. 2,030,328, Feb. 11, 1936 (July 11, 1932).

Laminated glass and method of making. J. G. MCNALLY (Eastman Kodak Co.). U. S. 2,029,931, Feb. 4, 1936 (July 29, 1932).

Lenses. W. J. TENNANT (American Optical Co.). Brit. 440,853, Jan. 22, 1936 (Dec. 21, 1934).

Manufacture of fabricated glass articles. OTTO FRITZE AND ALFRED RÜTTENAUER (General Electric Co.). U. S. 2,030,439, Feb. 11, 1936 (Dec. 18, 1934).—A gaseous electric discharge lamp device comprises a container, electrodes sealed therein, gaseous atmosphere therein, a coating of light-transmitting enamel on the inner surface of the container and luminescent material embedded in the surface of the enamel coating, the luminescent material having a smooth, glassy surface, the gaseous atmosphere emitting visible light and ultra-violet light when excited by the passage of an electric discharge between the electrodes, and the luminescent material being transparent to the visible light and transforming the ultra-violet light into visible light to complement the spectrum of the visible light emitted by the gaseous atmosphere and to supplement the intensity of the visible light.

Manufacture of fabricated glass articles. OTTO FRITZE AND ALFRED RÜTTENAUER (General Electric Co.). U. S. 2,030,440, Feb. 11, 1936 (Dec. 20, 1934).—A process for applying luminescent material to the inner surface of the container of an electric lamp.

Method of cooling glass. CORNING GLASS WORKS. Brit. 440,872, Jan. 22, 1936 (Feb. 28, 1935).

Method of producing nonshatterable glass. WALTER PEGLER (Joseph Leslie Pegler). U. S. 2,030,607, Feb. 11,

1936 (Aug. 28, 1935). A method of producing safety glass consists in soaking gelatine in water, then heating it until it becomes fluid, mixing formalin and glycerine in approximate proportion of one teaspoonful of glycerine to five ounces of the gelatine with a small amount of formalin, applying the solution thus produced to the surface of a sheet of glass, causing evaporation of moisture, then immersing the glass in a bath of formalin of about 60% of water and 40% of formaldehyde, removing the coated glass therefrom, and permitting the film to dry and then placing the glass, film side up, in a bath of resin of Canada balsam in solution, withdrawing the sheet of glass from the resinous bath, and drying.

Multifocal ophthalmic lens and blank therefor. J. H. HAMMON. U. S. 2,029,479 and 2,029,480, Feb. 4, 1936 (May 31, 1933).

Process for the manufacture of safety glass. W. W. GROVES (Deutsche Celluloid-Fabrik.). Brit. 440,887, Jan. 22, 1936 (July 2, 1934).

Production of dropping bottles. W. LIMBERG & CO. AND H. KRATZ. Ger. 608,606, Jan. 10, 1935 (Oct. 1, 1932), VI/32*a*, Gp.15; *Jour. Soc. Glass Tech.*, **19** [74] A208 (1935). —After making the bottle with the longitudinal groove in the neck, the latter is ground almost to the finished state by a grinding spindle of the same size as the stopper, which is then itself ground in with the minimum wear.

Production of multicolor patterns on glassware. W. BECKER. Ger. 608,263, Dec. 27, 1934 (Dec. 11, 1933), VI/32*b*, Gp. 9; *Jour. Soc. Glass Tech.*, **19** [74] A203 (1935). —In a process for producing decorated effects by an internal parison out against several colored or colorless glass sheaths or coverings, at least one of the intermediate layers is cut away to form a pierced design through which the inner glass is blown to unite with an outer layer.

Removing iron compounds from glass while molten. GLASWERK G. FISCHER. Ger. 615,753, May 9, 1935 (Dec. 16, 1933), VI/32*b*, Gp. 2; *Jour. Soc. Glass Tech.*, 19 [75] A264 (1935).—To the melt while molten is added a halogen compound which is vaporized at a temperature below 450° and at a pressure corresponding to atmospheric plus that of the column of glass.

Sandblasting inner surfaces of tubes. A. GUTMANN A.-G. FÜR MASCHINENBAU. Ger. 611,430, March 7, 1935 (Oct. 30, 1931), XII/67*b*; *Jour. Soc. Glass Tech.*, 19 [75] A300 (1935).—The nozzle is set at an angle on the end of a tube which is introduced down the inside of the cylinder to be treated, and means are provided for rotating the latter while the spraying material, *e.g.*, sand or fluid metal, is passed down the stationary center tube to the distributing nozzle.

Sodium resistant glass. LOUIS NAVIAS (General Electric Co.). U. S. 2,030,389, Feb. 11, 1936 (Aug. 11, 1934).—In combination with an electrical discharge device which contains a quantity of chemically active material and comprising a container which is susceptible to chemical attack by the material, a lining for the container comprises a borosilicate glass, the boric anhydride content of which is within the limits of about 50 to 75%, the silica content of which is within the limits of about 3 to 15%, and the oxide of alkali metal is less than about 10%.

Stacking bottles in the leer. H. SEVERIN. Ger. 613,312, April 25, 1935 (Dec. 16, 1931), VI/32*a*, Gp. 34; *Jour. Soc. Glass Tech.*, **19** [75] A296 (1935).—The bottles are introduced on the end of a horizontal arm in a gripping device capable of tipping which sets them in an upright position on the leer belt without shock.

Stoppering and grinding conical surfaces. C. KLEIN AND O. SPATZ. Ger. 610,351, Feb. 14, 1935 (July 21, 1932), XII/67*a*, Gp. 31_{01}; *Jour. Soc. Glass Tech.*, **19** [75] A301 (1935).—Grinding members on the ends of rods are moved in and out of the aperture to be ground by their rotation over the surface of the disk of wedge shape.

Suction machine. EUROPÄISCHER VERBAND DER FLASCHENFABRIKEN G.M.B.H. Ger. 607,177, Dec. 6, 1934 (Oct. 7, 1932), VI/32*a*, Gp. 13; *Jour. Soc. Glass Tech.*, 19[74] A177 (1935).—The rise and fall of the parison mold is operated by the fall and rise of the finish mold by means of suitable mechanism.

Tempering glass sheets. PILKINGTON BROS., LTD., L. J.-B. FORBES, AND J. WILSON. Brit. 441,017, Jan. 22, 1936 (July 10, 1934).

Tilting cutting table. PILKINGTON BROS., LTD. Ger. 611,619, March 14, 1935 (Jan. 3, 1934), VI/32*a*, Gp. 33; *Jour. Soc. Glass Tech.*, **19** [75] A300 (1935).—A tilting table for cutting sheet glass is provided with a fixed ledge, against which the sheet rests, and also with pivoted end pieces which serve to raise the sheet from the ledge for removal when the table is swung into the erect position.

Timing mechanism for glass feeders. O. M. TUCKER AND W. A. REEVES (Hartford-Empire Co.). U. S. 2,030,804, Feb. 11, 1936 (Oct. 24, 1913; Nov. 17, 1926).

Toughening sheet glass. R. MEER. Ger. 610,896, Feb. 28, 1935 (Nov. 1, 1933), VI/32*a*, Gp. 30; *Jour. Soc. Glass Tech.*, **19** [74] A202 (1935).—Between the furnace and the leer an intermediate chamber is provided through which the suspended sheets pass so that at the same time a sheet is fed from there to the furnace and from the furnace to the leer.

Toughening sheet glass, etc. L. MOSMIERI. Ger. 612,549, April 4, 1935 (June 17, 1933), VI/32*a*, Gp. 30; *Jour. Soc. Glass Tech.*, **19** [75] A296 (1935).—The hot air in the region of the heated sheets is sucked away by a number of apertures in a surrounding chamber which is kept exhausted.

Turnover table for glass sheets. WILLIAM OWEN (Pittsburgh Plate Glass Co.). U. S. 2,028,917, Jan. 28, 1936 (May 25, 1935).

Structural Clay Products

Adobe road surfaces calcined in place. ANON. *Eng. News-Rec.*, **115** [6] 185 (1935).—A slow-moving downdraft furnace traveling 10 ft./hr. was utilized for road construction in "black soil" areas (equivalent to adobe soils) in Australia in localities where the haul for gravel and crushed rock is excessive. G.R.S.

Giants in the brickmaking industry. LONDON BRICK COMPANY & FORDERS, LTD. *Elec. Rev.*, **118** [3032] 24 (1936).—The electric powered machinery used at the Stewartby works near Bedford in the production of ten million brick weekly is described in detail. Illustrated. J.L.G.

Pre-stressed ceramic members. F. O. Anderegg and C. L. Dalzell. *Proc. A.S.T.M.*, 35 [Part II] 447–56 (1935).—The method of construction and pre-stressing of testing units from face brick and hollow tile are described. The conclusions drawn from this study are as follows: (1) Building members assembled by the methods described developed noteworthy stiffness which seems to be dependent to a considerable extent upon the amount of pre-stressing. (2) The beams showed excellent load-carrying capacity relative to their cross-sectional area and weight. (3) The ultimate bending moment seems to vary with the pre-stress. (4) Failure in the long beams with center loading was in compression; the shorter beams, or the longer beams under multiple loading, failed in diagonal tension (or shear). (5) The stiffness of members and the comparatively small amount of bending of the stress-strain curve should help to simplify the design of such beams. (6) Accurate control of the pre-stressing operation, readily secured, is important. (7) Pre-stressing apparently causes a shift upward of the neutral axis. On loading the member this axis approaches the bottom ceramic fiber, as the initial compressive pre-stress thereon is neutralized, probably followed by a rise again with additional loading. (8) Columns of remarkable load-carrying capacity, even when quite slender, have been fabricated. (9) Savings can be secured by reductions in weight and volume over present building members. (10) These members, properly protected at the ends, are fireproof and weatherproof, thereby materially increasing the savings. R.A.H.

Reclaiming brick pavements. F. A. Daum. *Proc. Nat. Paving Brick Assn.*, p. 60 (1935).—By carefully removing the brick from brick roads where the base or bedding materials have failed they can be reused. D. cites a case where the brick were removed, cleaned, and replaced. The resulting road proved highly satisfactory. M.C.S.

Reinforced brickwork in Indian earthquake. Mason Vaugh and A. T. Mosher. *Eng. News-Rec.*, 115 [22] 738–39 (1935).—Floors, ceilings, and lintels were undamaged but in many cases were not tied to connecting elements. Lack of reinforcement in vertical walls was a major cause of failure. G.R.S.

Resurfacing municipal pavements with brick. M. P. O'Brien. *Proc. Nat. Paving Brick Assn.*, p. 48 (1935).—Almost any type of old or badly worn road constructed of either brick, macadam, or concrete serves admirably as a base for a new brick road. The maintenance cost of such a road is very much lower than would be required for a new road from the base up. The final quality of the road is largely determined by the bedding material and the paving units used. M.C.S.

Thin slab of brick and metal lath shows high strength and low cost. Anon. *Eng. News-Rec.*, 115 [1] 8–25 (1935).—Reports are given of tests made on three slabs consisting of one course of brick laid on metal lath and grouted. G.R.S.

PATENTS

Brick. F. B. Dunn. U. S. 2,029,814, Feb. 4, 1936 (Oct. 9, 1933).—A brick has a diagonally extending lug projecting outwardly from each of its ends, the lug on one end of the brick extending diagonally oppositely to the lug on the opposite end of the brick.

Building block. A. J. Schmitz. U. S. 2,028,997, Jan. 28, 1936 (June 30, 1933).

Drain-tile connector. M. R. Gutman. U. S. 2,029,920, Feb. 4, 1936 (March 17, 1934).

Metallic backings for paving blocks, road, and other surfaces subject to loads or stresses. B. Hird. Brit. 440,200, Jan. 8, 1936 (June 21, 1934).

Refractories

Alumina crucibles. Anon. *Pottery & Glass Rec.*, 17 [12] 319 (1935).—Alumina crucibles up to 3½ in. high, made by Thermal Syndicate, Ltd., Wallsend-on-Tyne, England, will endure a working temperature of 1950°C, *i.e.*, about 800°C above that of silica crucibles. A.B.S.

Behavior of refractory materials in continuous vertical retorts. A. T. Green. *Trans. Inst. Gas Engrs.*, 80, 147–69 (1930–31); for abstract see *Ceram. Abs.*, 10 [3] 197 (1931). G.H.A.

Corrugated suspended arches and walls. Anon. *Combustion*, 7 [1] 36 (1935).—A new design of refractory for suspended arch and wall construction is illustrated. The corrugations on the refractories are so designed that the longitudinal joints in an arch and the vertical joints in a wall can be either straight-line or offset. This type of construction is believed to reduce spalling, prevent the possibility of furnace gases or flames working up through the refractory with a plus pressure condition, and prevent molten slag from running along the joint and cutting it out. H.E.S.

Denver Fire Clay Company. Anon. *Ind. Eng. Chem., News Ed.*, 13 [2] 27–28 (1935).—The development of this company and its products is reviewed and illustrated. F.G.H.

Determination of thermal conductivity of refractories. Report for American Society for Testing Materials, Subcommittee C-8. P. Nicholls. *Bull. Amer. Ceram. Soc.*, 15 [2] 37–51 (1936).

Fireclay refractories for glassworks use: VII. Anon. *Glass*, 12 [7] 284 (1935). **VIII.** *Ibid.*, [8] 332.—The development of glasshouse refractories capable of withstanding the destructive action of glass batches requires a thorough knowledge of the various refractory material capabilities. As a rule, glasspot refractories are composed of blends of two or more specific refractories so proportioned as to impart the maximum in (1) resistance to glass erosion and solution and (2) mechanical strength. High silica clays exhibit the best resistance to thermal shock at the working temperatures of the glass batch, clays containing 26 to 30% alumina showing a coefficient of expansion 1.7 times that of high silica clays. The high alumina clays also show continued shrinkage over a period of usage while the high silica clays attain and hold a constant volume. High silica clay pots were found to keep their shape to the end of their life while the more aluminous clays sagged and bulged. Superiority of aluminous clays over highly siliceous clays was found in (1) high tensile strength and (2) resistance to solution. In spite of the in-

creased resistance to solution of the more aluminous clays, the material actually dissolved from such clays is a much greater nuisance in the glass than the larger amount dissolved from the high silica clays. IX. *Ibid.*, [9] 372.—The chief quality necessary in glasspot stoppers is the ability to withstand sudden temperature changes. It appears that refractories with the most complete development of mullite and the minimum amount of glass bond serve best for this purpose and also give reasonable resistance to glass attack. Gathering rings do not require as high a resistance to spalling as pot-tops but their resistance to solution should be much greater. To meet these requirements it is usually best to use a body of fine grog and bond clay both of a high silica content and free from segregated iron. Small additions of feldspar may be added to aid in the vitrification of the block. Tank blocks that have been used with the greatest success were made from materials having a maximum development of mullite with a good bond for a close structure. Sillimanite, electrocast mullite, certain high silica clays, and the natural Penshaw stone have also served well for this purpose. For Parts V–VI see *Ceram. Abs.*, 14 [10] 248 (1935).

M.C.S.

Graphical representation of calculating heat loss through furnace walls. C. E. Weinland. *Jour. Amer. Ceram. Soc.*, 19 [3] 74–80 (1936); see also *Ceram. Abs.*, 15 [2] 63 (1936).

Physicochemical considerations in the production of refractory materials. Marcel Lépingle. *Métaux & Machines*, 19, 117–20 (1935); abstracted in *Chem. Zentr.*, ii, 2421 (1935).—A detailed discussion of the phase diagram of some aluminum silicates is given. *Métaux & Machines*, 19, 257–62 (1935); abstracted in *Chem. Zentr.*, ii, 3279 (1935).—The physical chemistry of quartz and its transformations is discussed in detail. M.V.C.

Refractories. H. A. Morlock. *Can. Chem. Met.*, 20 [1] 14 (1936).—A large proportion of the refractories used are earthy oxides in brick form, blended, molded, and fired at high temperatures to develop the necessary strength of bond. The economic use of refractories entails proper combustion design of furnaces for the fuel selected, correct strength and proper design of supporting steelwork, and intelligent bricklaying. The two groups of furnaces, continuously and intermittently operated, may be classed as (1) simple heating devices, (2) furnaces for processing where the product is of a fluxing nature but not molten, and (3) furnaces for melting or processing molten materials. The refractory destroying factors are temperature, spalling, fluxing, overloading, and abrasion. Refractories are divided into acid, basic, and neutral groups, according to their chemical behavior. Silica brick, magnesite brick, and chrome brick are the principal examples of the three types of brick. Fireclay brick is used probably to a greater extent than any other refractory and has the most widespread variations. The de-airing process and lightweight cellular structure fireclay brick are discussed as recent developments. E.J.V.

Relationship between refractoriness under load and grain size of grog in the mix. Jerzy Konarzewsky and Stanislav Rusiecki. *Przemysl Chem.*, 18, 441–44 (1934); abstracted in *Chem. Zentr.*, ii, 2865 (1935).—The brick studied consisted of a mixture of clay and grog in the ratio of 1:1, were fired to 1300°C, and differed only in the grain size of grog. It was found that brick containing a larger amount of fine-grained grog had a higher softening point; the difference amounted to 50 to 120°C in the same group. M.V.C.

Silicon carbide serves as heat-exchange medium. H. L. Read and F. L. Fritsche. *Steel*, 96, 39–41, 44 (Feb. 25, (1935); *Met. Abs.*, 6 [7] 284 (1935).—For minimizing cracks and leakage in refractory recuperators, a joint has been developed which allows a slight movement in the setting. Silicon carbide is a satisfactory material for recuperators because of its extremely low cracking and spalling tendencies and great strength and thermal conductivity at high temperatures. Rate of heat transfer is greater than with other refractories due to the higher air velocities, without serious leakage, which can be used. Applications to steel-mill furnaces are described.

Sillimanite and mullite. Anon. *Giornali Chimici*, 29, 8–10 (1935); abstracted in *Chem. Zentr.*, ii, 1593 (1935).—The production, properties, and application of sillimanite and mullite are discussed. M.V.C.

Thermal insulators and their application. A. Clousset. *Verre & Silicates Ind.*, 6 [24] 425–27 (1935).—The relative value of different means of insulation, the coefficient of dispersion of heat, and the evaluation of the loss of heat of furnace masonry are discussed. M.V.C.

BOOK

Directory of the Iron and Steel Works of the United States and Canada. 22d ed. American Iron and Steel Institute, N. Y., 1935. 414 pp. Price $10.00. Reviewed in *Jour. West. Soc. Engrs.*, 40 [6] 289 (1935).—This is the first edition of this reference volume since 1930, and it brings data on 330 iron and steel works up to date. In general, the date of incorporation and number of shares of stock outstanding are given, followed by the names of the executive officers, sales offices or agents, brief descriptions of the works, and data on the products made and annual capacities. In a supplement is a summary of annual capacities by products, companies, and states. To facilitate comparisons with earlier editions, a special list has been included in this volume, containing appropriate reference to all concerns, the names of which were listed in the 1930 edition, but which have since that date gone out of business, have been combined with other companies, or have changed ownership and corporate name.

PATENTS

Ceramic object and method of making. J. L. Gallup (Radio Corporation of America). U. S. 2,030,200, Feb. 11, 1936 (March 30, 1934). The method of making a substantially pure alumina object which is substantially unchanged at about 1600°C comprises making a mixture consisting of 70 to 90% of substantially pure alumina particles measuring about 75 to 100 microns across and the remainder of substantially pure alumina particles measuring from 2 to 8 microns across, adding water to make a slip just thin enough to pour, casting the slip into the desired object, and firing the shaped object at from 1450° to 1600°C to make it coherent and strong.

Decalcification of magnesium dolomites. C. D. Wygal (Inland Lime and Stone Co.). U. S. 2,028,639, Jan. 21,

1936 (Oct. 26, 1934). In the method of preparing magnesium bisulfite from a high magnesian rock containing calcium, the steps of calcining the rock to produce a mixture of calcium and magnesium oxides, adding water to the oxides and chlorinating the resulting mixture to chlorinate substantially all of the calcium without chlorinating substantial amounts of the magnesia, separating the residual magnesia, and treating it with sulfur dioxide to produce magnesium bisulfite.

Furnace fire bridges. A. E. JONES AND S. HODGE & SONS, LTD. Brit. 440,897, Jan. 22, 1936 (July 27, 1934).

Manufacture of basic refractory material. R. L. LLOYD AND R. W. HYDE (Dwight & Lloyd Metallurgical Co.). U. S. 2,029,627, Feb. 4, 1936 (July 19, 1932). A method for the manufacture of refractory material comprises comminuting a raw material selected from the group consisting of magnesite and dolomite, mixing therewith fine-sized fluxing materials, bonding the mixture with a hydraulic cement comprising an oxychloride of an alkaline earth compound, converting the bonded mixture into coarse-sized pieces, as compared to the fine raw materials, adding fuel, and firing the mixture by forced-draft combustion of the intermixed fuel, whereby high temperatures are obtained at which the raw materials are transformed into a clinkered, hard-fired, refractory product.

Manufacture of pure alumina. VEREINIGTE ALUMINIUM-WERKE A.-G. AND T. GOLDSCHMIDT A.-G. Brit. 440,486, Jan. 15, 1936 (Sept. 20, 1933).

Process for obtaining products containing spinels. T. R. HAGLUND. U. S. 2,029,773, Feb. 4, 1936 (May 17, 1933). A process for producing highly refractory products, consisting in the main part of spinels of the type $RO \cdot R_2O_3$, comprises fusing raw materials containing spinel-forming oxides and silica and lime while regulating the charge so that the solidified molten mass consists of spinels and silicates rich in calcium, the latter being present to at least 20%, and removing (at least partly) compounds of calcium from the solidified mass.

Whiteware

Care of china. EDWARD SCHRAMM. *Bull. Amer. Ceram. Soc.*, **15** [2] 66–68 (1936).

Influence of glaze composition on the mechanical strength of electrical porcelain. L. E. THIESS. *Jour. Amer. Ceram. Soc.*, **19** [3] 70–73 (1936).

Insulator arcover in air. F. W. MAXSTADT. *Elec. Eng.*, **53**, 1062–68 (1934).—A theory of arcover is offered. The geometrical design of an insulator is shown to be a minor factor at power frequencies but of importance for withstanding impulse voltages. G.M.P.

Manufacture of high-voltage porcelain insulators. J. M. SOMERVILLE. *Eng. Jour.*, **19** [1] 23–30 (1936).—The methods of scientific control of the materials and processes employed in the manufacture of porcelain insulators are described, together with the technic and equipment used. Particulars are given as to the physical and electrical properties of the finished material and the tests applied. Illustrated. E.J.V.

Manufacture of laboratory apparatus and insulators from sillimanite in U. S. A. P. P. BUDNIKOFF. *Amer. Tekh. Prom.*, No. 7, pp. 213–19 (1933); abstracted in *Referat. Silikatliteratur*, No. 620 (1934). M.V.C.

Plastic flow in a nearly dry clay body. H. THIEMECKE. *Jour. Amer. Ceram. Soc.*, **19** [3] 67–70 (1936).

Proposed symposium on body and glaze properties, White Wares Division, American Ceramic Society. ROSS C. PURDY, *et al.* *Bull. Amer. Ceram. Soc.*, **15** [2] 56–60 (1936).

BOOK

Insulators for High-Tension Installations. A. I. APRAKSIN AND I. I. IL'IN. Edited by S. A. Krasnogorodtsev. United Sci. Tech. Pub. House of Heavy Ind., U.S.S.R. Chief Ed. Office of Energetical Literature, Leningrad, 1935. 94 pp. Price 75k. This illustrated brochure deals with different types of insulators, their design, uses, tests, specifications, etc. S. I. PERKAL

PATENTS

Condenser. RALPH HIGGINS (Ohio Brass Co.). U. S. 2,028,907, Jan. 28, 1936 (Nov. 3, 1932).

Dental porcelains and cements. BAKER & CO., INC. Brit. 440,302, Jan. 8, 1936 (Dec. 5, 1934).

Single insulator fuse mounting. A. G. STEINMAYER (Line Material Co.). U. S. 2,028,421, Jan. 21, 1936 (June 9, 1934).

Water closet. C. H. ZWERMANN, HELENE ZWERMANN, AND CARL H. ZWERMANN, JR. (W. A. Case & Son Mfg. Co.). U. S. 2,030,559, Feb. 11, 1936 (July 30, 1932).

Water-closet construction. J. N. MURPHY (August F. Maurer). U. S. 2,028,468, Jan. 21, 1936 (Aug. 22, 1934).

Equipment and Apparatus

Adsorption and pycnometry. P. G. NUTTING. *Jour. Wash. Acad. Sci.*, **26**, 1–6 (1935).—The apparent density of quartz, Pyrex-brand glass, and several clays after various conditioning treatments has been determined by pycnometry of high precision. Conclusion: the pycnometer method may be used to study adsorption but it is tedious and troublesome and less satisfactory than more direct methods. It does have a possible usefulness in studying changes in grain volume on hydration or dehydration, in differentiating between internal and external water, and in determining pore size in dehydrated crystals. J.B.A.

Alloy steels for temperatures over 800°F in boiler drums, super-heaters, and steam piping. G. K. HERZOG. *Combustion*, **7** [1] 21–24 (1935).—H. reviews the physical properties of the principal alloy steels suitable for high-temperature, high-pressure steam service and gives a brief explanation of the function of the various alloying elements in meeting creep, satisfying tensile and fatigue requirements, impact, corrosion, and oxidation at elevated temperatures. H.E.S.

Aspects of de-airing generally overlooked. J. OTIS EVERHART. *Brick Clay Rec.*, **88** [1] 23–25 (1936).—The

de-airing principle is, in general, applicable only to improving forming and drying properties of so-called difficult clays. Tempering of the clay is greatly improved by de-airing, with decreased work. The sealing phases of de-airing equipment are an important part of the process. Different materials have different inherent sealing values. In a given sealing set-up, change of volume of material and of moisture will affect sealing values. Change of vacuum and wear of the machine parts will affect sealing conditions. Evacuation phases involve consideration of time, space, and method. In forming de-aired material it has been found that modified forming pressures and modified lubrication are effective but such practices must be in keeping with sound principles of production. De-aired material is characterized by such superior forming and die flow that even dies which are badly unbalanced will produce a column which looks entirely sound as it leaves the die and goes through the cutter. This often causes trouble in drying. With de-aired ware, drying conditions are improved in virtually all cases where attention is paid to drying fundamentals and modifications are made for de-airing. Tests to determine the effect of de-airing on firing of the ware should be made by manufacturers. E.J.V.

Automatic continuous weigher-feeder. Syntron Co. *Instruments*, **9** [1] 25 (1936).—This equipment automatically feeds dry or moist materials, other than fluids, at a constant rate on the basis of weight regardless of bulk. R.W.R.

Centrifugal boiler-feed pumps for high pressures. A. Peterson. *Combustion*, **6** [11] 8–13 (1935).—American and European practices are compared. H.E.S.

Color analyzer. General Electric Co. *Enamelist*, **13** [4] 20–21 (1936); see *Ceram. Abs.*, **12** [12] 428 (1933). E.J.V.

Corrosion of iron in the presence of and absence of oxygen. S. Alfano. *Combustion*, **6** [12] 21–27 (1935).—The fundamental chemical principles underlying corrosion are reviewed. Due to the inherent solution pressure of iron it will dissolve until it reaches its saturation value, but with oxygen present it is precipitated and the corrosive action goes on. Methods of measurement and the effect of p_H values are discussed, and the problem is presented from the standpoint of the power plant operator. H.E.S.

Determination of the wall correction for the falling sphere viscometer. E. I. Fulmer and J. C. Williams. *Jour. Phys. Chem.*, **40** [1] 143–49 (1936). C.J.P.

Dust separation practice. Editorial. *Indian Engr.*, **90** [16] 336 (1931).—An account is given of 64-inch "Davidson" dust collectors of the "D" type, operating on the combined centrifugal and gravity principle, and capable of separating 95% of the total dust in the chimney gases, including extremely fine dust. A.P.S.

Fume exhaust systems. B. F. Postman. *Heating, Piping & Air Conditioning*, **7** [12] 572–74 (1935).—The selection of fan and motor and the design of the exhaust duct system are considered with the aid of diagrams and graphs. J.L.G.

Furnace for the measurement of coal-ash softening temperature. Elliott P. Barrett. *Proc. A.S.T.M.*, **35** [Part II] 627–42 (1935).—A furnace for the specific purpose of determining softening temperatures of coal ash, which is readily adaptable to measuring cone deformation temperatures up to 3000°F (1650°C), is described. The furnace is of the horizontal muffle type and is constructed to permit the cones to be viewed against a background somewhat lower in temperature. The results obtained with this furnace do not differ from those obtained with the conventional pot furnace. A critical discussion of the technic of ash-softening measurements is presented. R.A.H.

Hydrogen electrode for p_H determinations. H. C. Lockwood. *Jour. Soc. Chem. Ind.*, **54** [35] 295–96 (1935).—Diagrams and descriptions are given of four types of improved electrode vessels. G.R.S.

Image distortion and other effects due to the glass thickness in lens systems: I–II. H. Dennis Taylor. *Proc. Phys. Soc.* [London], **46**, 283–91, 889–96 (1934).—The first part of this paper discusses the optical influence on the distortion of the image, or departure from correct pictorial representation, caused by the considerable thickness of glass involved in the construction of high-class photographic lenses or projectors of a large angular field of view. Specific instances of such influence and the appropriate formulas for expressing the amount of such distortion are given. In the second part of this paper the formulas are applied to Cooke Series V lenses of 10-in. equivalent focal length. L.E.T.

Mathematical method for direct comparison of values obtained with different test pieces on ceramic stress-testing apparatus. W. Stroer. *Ber. deut. keram. Ges.*, **16** [6] 287–96 (1935).—Using an apparatus described previously (*Ceram. Abs.*, **7** [9] 625 (1928); **10** [3] 206 (1931); **12** [2] 71 (1933)), results obtained on specimens of different kinds were found not directly comparable because the dimensions of the bars and the moduli of elasticity of the bodies were not the same. Formulas are developed whereby the values obtained are related to a standard specimen having the following properties: modulus of elasticity 5000 kg./mm.^{2}; dimensions of the middle glazed portion of rectangular cross-section, length 100,000 mm., width 14,815 mm., thickness 3000 mm. E.J.V.

Measurement of particle-size distribution by optical methods. R. N. Traxler and L. A. H. Baum. *Proc. A.S.T.M.*, **35** [Part II] 457–71 (1935).—Studies were made of the various factors influencing the determination of particle-size distribution by means of the Wagner turbidimeter. A technic was developed for the dispersion of the finely pulverized solids. For the accurate investigation of particle-size distribution in mineral powders of the types here studied, the turbidimeter is apparently unreliable, but for the detection of changes in size distribution in a single product the method is no doubt of practical value. R.A.H.

Mechanical analysis of the ultimate natural structure of soils. G. J. Bouyoucos. *Soil Sci.*, **40** [6] 481–85 (1935).—A combination of the sieve method and the hydrometer method was finally adopted for the purpose of making a mechanical analysis of the ultimate natural structure of soils. As a rule the ultimate natural structure of most soils seems to be coarse, ranging in size from about 2.0 to 0.15 mm. Many soils have more than 90% of their particles or aggregates in this range. G.R.S.

Microchemical equipment and improvements in micro-

chemical laboratory methods: I–II. HERBERT K. ALBER. *Mikrochemie*, **18** [1] 92–111; [2] 289–318 (1935).—A series of new equipment and devices for microchemical laboratory work is described. Part I deals with such devices as the electric micro-muffle, apparatus for thermal decomposition of small quantities of materials in inert atmosphere, apparatus for micro-distillation, and a preheater for micro-analytical determination of carbon and hydrogen. Part II deals with capillary syphon pipets, micro-filtration apparatus, micro-burets, vacuum micro-desiccator, etc. L.E.T.

Muck and marl sampler. ROBEY MFG. CO. *Instruments*, **9** [1] 27 (1936).—The complete outfit comes in a carrying case containing handle and sampler tube in seven 30-in. sections. With all sections assembled a sample may be taken at a depth of 20 ft. Tubes are of heavy $^3/_4$-in. brass tubing. The sample chamber is so designed that it does not fill while the tubing is pushed down with a slight clockwise motion; when proper depth is reached, the operator turns the handle counter clockwise, causing a sample to be sheared off and forced into the chamber. The chamber is then closed by turning the handle to the right, so that the sample is brought up without risk. R.W.R.

Oil-fired assay furnace. G. S. COMPTON AND C. MEHARRY. *Chem. Eng. Mining Rev.*, **28**, 53–54 (Dec., 1935). H.H.S.

Pipet method in grain-size analysis, with special reference to the examination of mineral colors. A. H. M. ANDREASEN AND S. BERG. *Angew. Chem.*, **48** [20] 283–85 (1935).—During recent years a new sedimentation apparatus for measuring particle-size distribution has been developed. The pulverulent material is evenly dispersed through a liquid. By means of a pipet a small sample of the liquid is withdrawn at definite time intervals and from a definite depth. The amount of solid material in the sample is determined. The concentration of the solid material in the sample divided by the original concentration is a measure of that portion of the material whose particles are smaller than a definite size, which size may be determined by the rate of fall of known particles, the depth from which the sample was taken, and the time at which it was removed. The apparatus is described and measurements of the size distribution in various mineral pigments are reported to show the limitations of the method. L.T.B.

Pyrometers for power stations. EDITORIAL. *Indian Engr.*, **90** [13] 276 (1931).—Pyrometers are described of the thermoelectric type with temperature measurements at 15 points for the turbine and 12 points in each boiler and accessory equipment. A.P.S.

Recording microphotometer. C. F. CASELLA AND CO., LTD. *Jour. Sci. Instruments*, **12** [4] 128–29 (1935).—The instrument is similar to Moll's in that it uses a thermocouple and galvanometer in place of the photoelectric cell. This secures a constant linear relationship between incident light and galvanometer deflection. A slit reduces the illuminated area on the plate to the width of the analyzing beam. The three optical units, (*a*) lamp and condensing lens, (*b*) fine slit and apochromatic objective, and (*c*) another objective and the sensitive thermocouple, are geometrically mounted on rods for exact adjustment of the collimation. Response time of the system is 0.3 sec. The photographic plate carriage which travels perpendicularly across the line of the optical system is adjustable for height to bring the various spectra under the analyzing beam. Other adjustments bring the spectrum parallel to the line of motion of the carriage and bring lines on the spectrum parallel to the narrow light beam. The plate carriage is driven by a small motor through belts and reducing gears. The light-tight case for the recording drum of sensitized bromide paper contains a cylindrical lens for focussing the image of the galvanometer slit on the paper. Two sets of gears provide linear ratios of plate movement to drum movement of 6.89 and 48.2 to 1. Provision is made for recording a coördinate system which is independent of any changes of dimension of the paper during development and drying. Illustrated. J.L.G.

Relative floatability of silicate minerals. JOHN MARK PATEK. *Trans. Amer. Inst. Mining Met. Engrs.*, **112**, 486–509 (1935).—The purposes of this research were (1) experimental determination of differences in floatability between silicates, (2) investigation of the causes for such differences, and (3) discovery of a means of predetermining approximate floatability without the necessity of experiment. As obtained by flotation tests the relative floatability was found to be in ascending order: quartz and orthoclase, albite, nephelite, muscovite and labradorite, biotite, spodumene, anorthite, augite, rhodonite, titanite, tremolite, epidote, kyanite, olivine, topaz, almandite, and tourmaline (black) and zircon. Density may be correlated with natural wettability, the principal factor influencing the floatability. The action of the collecting agent on the contact angle is discussed in relation to Gaudin's theory that the principal factor governing silicate floatability is the ratio of the total number of valences of soap-forming atoms of base metals to the total number of valences of non-soap-forming atoms of alkali metals, water, and silicon. The empirical expression formulated for predicting floatability is as follows: Floatability equals specific gravity times the cube root of the valence ratio. A.P.

Repowered for profit. J. D. GRAYSON. *Factory Management & Maintenance*, **93** [12] 522–24 (1935).—The manner in which an industrial plant changed its power drives, using more and shorter line shafts and purchasing power in place of generating it, to save $8000 annually at an initial cost of $18,000 is described. Illustrated. J.L.G.

Respirator has double chemical cartridge. H. S. COVER. *Ind. Finishing*, **12** [1] 33 (1935).—The double cartridges of activated coconut charcoal provide increased filtering area with consequent slower air speed through the felt filter pads. This allows a higher proportion of dust and spray to be caught. A double low-resistance exhalation valve is used. The valve port at the bottom takes care of condensed moisture. Illustrated. J.L.G.

Rod thermostat. BURLING INSTRUMENT CO. *Instruments*, **9** [1] 27 (1936).—Utmost simplicity combined with greatest adjustability is claimed for the new Model D and Model M (with and without outside adjustment knob) expansion-stem temperature controllers. Action is "on-and-off," the inner rod operating a switch through a bell-crank lever. Maximum temperature is 1800°F, and normal operating limits are from 50°F to 1600°F. The adjustable

range may be as short as 100° or as long as 1000°. The differential may be ±1°F or ±25°F. The switches are snap-action, normally open, normally closed, or double-acting, or three wire, all rated at 10 amps., 110 v. a.c. R.W.R.

Sedimentation tube for analyzing water-stable soil aggregates. RALPH C. COLE AND N. E. EDLESEN. *Soil Sci.*, **40** [6] 473–79 (1935).—The tube described was designed to measure the size distribution of individual and compound particles present when a soil is slaked in water. The procedure in making a determination and a diagram of the sedimentation tube are given. G.R.S.

Semiautomatic potentiometer for thermal analysis. R. M. J. PAYNE. *Jour. Sci. Instruments*, **12** [11] 348–55 (1935).—P. describes a mechanically driven potentiometer designed for use with an inverse rate recorder in making thermal curves of metals and alloys. It is suited to autographic recording of variation of any property of a material which can be estimated in terms of e.m.f., provided that d/dt of the function does not change sign and also that it is small enough for the galvanometer and potentiometer to follow. Illustrated. J.L.G.

Washing in filtration. F. H. RHODES. *Ind. Eng. Chem.*, **26** [12] 1331 (1934).—An equation is developed which expresses the concentration of the wash water from a filter press as a function of the initial concentration of soluble material in the cake, rate of flow of wash water, thickness of the cake, and an experimentally determinable equilibrium constant. Illustrated. F.G.H.

Wear test for flooring materials. J. R. SHANK. *Proc. A.S.T.M.*, **35** [Part II] 533–45 (1935). R.A.H.

Wet- and dry-bulb hygrometer at low temperatures. J. H. AWBERY AND EZER GRIFFITH. *Proc. Phys. Soc.* [London], **47** [4] 684–702 (1935).—The humidity corresponding to various wet- and dry-bulb temperatures between −2°C and −19°C was measured. The wet-bulb temperatures were obtained by means of mercury thermometers, thermocouples, and resistance thermometers, all methods agreeing well. The actual humidity was generally obtained from a specially designed dew-point apparatus. The results are utilized to prepare a table giving relative humidity at various wet- and dry-bulb temperatures. L.E.T.

PATENTS

Apparatus for comparing colors. J. E. SIMONS. U. S. 2,030,329, Feb. 11, 1936 (Sept. 22, 1934). A color comparing apparatus comprises a sight tube adapted to be directed at an object, a rotary drum mounted alongside of the tube and having a series of colors arranged on the inner periphery thereof and adapted to bring any one of the colors in side-by-side relation to the tube, an enclosure for the drum secured to the tube, a light chamber adjacent to the drum enclosure and adjacent to the tube and having means for illuminating the object and the color thus positioned, and a light passage leading from the color to the rear of the tube.

Apparatus for the manufacture of brick. G. E. ROGERS. U. S. 2,028,523, Jan. 21, 1936 (March 7, 1935).

Flowerpot-making machine. C. W. SCHMIDT. U. S. 2,029,084, Jan. 28, 1936 (Sept. 18, 1934).

Making patterned molds. N. NEUHAUSS, J. C. KITTLER, AND H. NEUHAUSS. Ger. 612,752, April 11, 1935 (March 19, 1932), VI/32*a*, Gp.7; *Jour. Soc. Glass Tech.*, **19** [75] A269 (1935).—The mold, or its inner face, is formed with the desired configuration by pressing, stamping, or like process from a sheet of heat-resisting austenitic steel.

Powder-spraying appliance. SVEND BRAMSEN, FRITZ WAHLIN, AND ERIC GUSTAFSON (Binks Mfg. Co.). U. S. 2,029,408, Feb. 4, 1936 (June 29, 1933).

Process of making expanded vermiculite. P. S. DENNING (F. E. Schundler & Co., Inc.). U. S. 2,029,524, Feb. 4, 1936 (Jan. 21, 1932).

Pyrometers. W. J. CLARK AND IMPERIAL CHEMICAL INDUSTRIES, LTD. Brit. 440,188, Jan. 8, 1936 (May 23, 1934).

Spray gun. F. R. DIPPMAN (Ohio Brass Co.). U. S. 2,029,061, Jan. 28, 1936 (Sept. 2, 1931).

Kilns, Furnaces, Fuels, and Combustion

Coal for brickworks. W. H. GAMBLE AND R. F. PAGET. *Brit. Clayworker*, **44** [525] 311–14 (1936); for abstract see *Ceram. Abs.*, **15** [3] 102 (1936). R.A.H.

Determining moisture in coal. W. H. WOOD. *Combustion*, **7** [2] 16 (1935).—A speedy, accurate method of determining moisture in fuel is to remove the moisture by distillation and then condense and measure it. Illustrated. H.E.S.

Dissociation of products of combustion. W. L. DEBAUFRE. *Combustion*, **6** [11] 23–31 (1935).—Tables and curves are given by means of which dissociation of products of combustion may be calculated and corrections made to the thermal properties of products of combustion at high temperatures. Thermodynamic relations and experimental data show that actual conditions closely correspond to results calculated in this way. In special cases, however, dissociation of molecular hydrogen into atomic hydrogen, association of nitrogen and oxygen into nitrous oxide, etc., may be sufficient to affect the results. For a discussion of these effects and of "the maximum temperatures and pressures attainable in the combustion of gaseous and liquid fuels," see *Univ. of Ill. Bull.*, No. 139. H.E.S.

Effect of ash on combustion characteristics of carbons. Y. OSHIMA AND Y. FUKUDA. *Ind. Eng. Chem.*, **27** [2] 212–17 (1935).—A weighing method of measuring the combustion characteristics of carbonaceous materials is described, and the results are analyzed graphically. Definitions of ignition temperature, combustibility, total rate of combustion, and direct combustion velocity are given. The ash in charcoal is conducive to pronounced catalytic lowering of the ignition temperature, while the combustion velocity after ignition is almost unaffected by the ash. On the other hand, coke ash retards the ignitibility more or less rather than catalyzes it. The cause of the different effects of coke ash and charcoal ash is discussed. The catalytic behavior of charcoal ash is observed also when certain inorganic and organic salts are added. Moreover, the catalytic effectiveness is shown to depend on the metallic as well as the negative component of the salt. Illustrated. F.G.H.

Electrically heated industrial furnaces. R. Boye. *Eng. Progress*, **16** [11] 265–72 (1935).—Resistance materials, insulation, and regulation for various types of electric furnaces are considered. Ceramic kilns or furnaces receive only brief consideration. Increased economy is claimed for electrically heated tunnel kilns. Illustrated. J.L.G.

Grading and classification of coal. H. Eustace Mitton and D. T. Davies. *Trans. Inst. Mining Engrs.*, **90** [1] 3–8 (1935). A.H.E.

Graphical analysis of combustion losses. H. M. Holaday. *Combustion*, **7** [2] 17–22 (1935).—Graphical methods that are adequate for most purposes are illustrated and described. H.E.S.

Heating values of fuels. J. S. Doolittle. *Combustion*, **6** [11] 14–15 (1935).—The determination of the heating values of liquid, solid, and gaseous fuels, at constant pressure and constant volume, is discussed. H.E.S.

Oil from coal. Anon. *Elec. Rev.*, **117** [3025] 666 (1935).—The electrical equipment at the National Coke & Oil Co., England, for producing oil from coal is briefly described. The raw materials are 93% coal and 7% creosote. The salable products are a high-grade motor spirit called "Napet" (over 15 gal./ton of coal), a smokeless fuel in small, hard blocks known as "Naco" (15.6 hundredweight/ton of coal), and a heavy oil which can be partly converted to Diesel oil. J.L.G.

Pneumatic dedusting of coal. S. R. Berrisford and R. H. Allen. *Trans. Inst. Mining Engrs.*, **89** [6] 298–334 (1935). A.H.E.

Pure coal. E. S. Grumell. *Trans. Inst. Mining Engrs.*, **87** [6] 260–77 (1934). A.H.E.

Observations on setting: IV. L. R. Whitaker. *Brick Clay Rec.*, **88** [1] 26–30 (1936).—By setting the header of the ring of the kiln in series to form a continuous line toward the center, a channel is formed for a horizontal flow of gas to the center of the kiln. The stability and resistance of brick to the "pull of the fires" is not only a question of ties, but the kiln bottom and method of setting must also be considered. An interesting problem in damper control is suggested during the heating and soaking period by watching the velocity at which flame enters the stretcher courses in a horizontal direction. The entire kiln system, including furnaces, setting, flue openings, flues, and stack or fan, may be considered as a continuous flue. The setting on the bottom of the kiln is an integral part of the flue openings. Various types of settings are considered in detail. Illustrated. For Part III see *Ceram. Abs.*, **14** [10] 247 (1935). E.J.V.

Virginia coals, their classification and analyses. P. B. Place. *Combustion*, **7** [1] 29–32 (1935).—P. identifies the different seams and the trade names of Virginia coals, reviews their qualities, and lists their importance from a production standpoint. The location, analysis, and characteristics of the various coals are given. H.E.S.

BOOK AND BULLETIN

Classification chart of typical coals of the United States. A. C. Fieldner, W. A. Selvig, and W. H. Frederic. *Bur. Mines Rept. of Invest.*, No. 3296, 22 pp. Free. Information is given on specifications for classification of coals by rank, with charts showing the B.t.u. of typical coals of the U. S., as well as a list of 316 coal samples given in the charts with their source and rank. R.A.H.

Electric Furnaces (Elektrische Oefen). **Part 4.** Edited by H. Alterthum. Akademische Verlagsges., Leipzig, 1935. Price 28R. Reviewed in *Met. Abs.*, **6** [11] 450 (1935).—This is the fourth of a six-part summary of German patents on electric furnaces. The first section of this part, pp. 145–76, continues a classification of patents by subject, covering smelting, carbon and carbides, and refractory materials. Patents are briefly listed with introductory historical comments. In the second section, pp. 321–448, abstracts of all German patents that concern electric furnaces or their accessories are given in the order of their numbers. This part covers patents 420,703 (1925) to 478,675 (1929). Abstracts are quite complete, often with drawings. This compilation should be valuable to those who may need to search German patent literature for information on electric furnaces.

Geology

Aluminum sulfate from domestic raw materials for the paper industry. E. Pyhälä. *Suomen Paperi-ja Puutavaralehti*, 191–92 (1935); abstracted in *Chem. Zentr.*, ii, 99 (1935).—The use of Finnish kaolin for the production of aluminum sulfate and aluminum metal is discussed with special emphasis on the successful treating of leucite (of similar chemical composition) according to the Alberto Blanc method in Italy (see *Ceram. Abs.*, **12** [7] 275 (1933)). M.V.C.

Andesite rock of Ditran. Virgile Ianovici. *Ann. Sci. Univ. Jassy* [Rumania], **20**, 86–97 (1935); abstracted in *Chem. Zentr.*, ii, 342 (1935).—A description is given of andesite and minerals it contains, such as feldspar, pyroxene, olivine, opal, calcite, and antigorite. M.V.C.

Availability of soil potassium. John Lamb, Jr. *Soil Sci.*, **40** [5] 365–81 (1935).—No relation was found between the total and exchangeable forms of soil potassium. Potassium starvation in the Ewing soil was associated with low exchangeable potassium and high exchangeable calcium. The methods used showed no significant difference in the rate at which exchangeable and water-soluble potassium were replenished from the reserve supply of the soils. G.R.S.

Biotite system. A. N. Winchell. *Amer. Mineralogist*, **20** [11] 773–79 (1935).—According to the theory presented, ferric iron in biotite was originally ferrous iron, which has been oxidized by natural processes. Diagrams showing the variations in composition and optic properties of annite, siderophyllite, phlogopite, and eastonite are included. F.J.Z.

Chemistry of minerals (orthite, biotite, etc.) of feldspar in Kangasala, South Finland. Lauri Lokka. *Bull. Commiss. Geol., Finlandi*, No. 111, 35 pp. (1935); abstracted in *Chem. Zentr.*, ii, 3219 (1935).—A description is given of feldspars, orthite and its transformation products, and biotite and its disintegration products, with data and analyses. M.V.C.

Chemistry and morphology of basic salts of two-valent

metals: I, General viewpoints. W. FEIKNECHT. *Helv. Chim. Acta*, **18**, 28–40 (1935); abstracted in *Chem. Zentr.*, ii, 1818–19 (1935). **II, Basic cobalt sulfates. III, Basic cobalt chlorides.** W. FEIKNECHT AND G. FISCHER. *Helv. Chim. Acta*, **18**, 40–60, 155–69 (1935); *Chem. Zentr.*, ii, 1819–20 (1935). M.V.C.

Chromium, its minerals and industry. MAURICE DÉRIBÉRÉ. *Métaux & Machines*, **18**, 309–12; **19**, 45–48 (1935); abstracted in *Chem. Zentr.*, ii, 2034 (1935).—A detailed discussion is given of (1) chrome ores (deposits, mining, analysis), (2) production and properties, and (3) chrome silicides, chrome steels, and alloys. Bibliography. M.V.C.

Clay production in China. W. H. WONG AND T. F. HOU. *China Yearbook*, **17**, 55 (1935). (Edited by H. G. W. Woodhead, Shanghai.)—Total annual production is one million tons. Kiangsi province (Fuliang, Singtsu, and Yukan districts) produces 150,000 T. of porcelain clay. Hopei province (Fengyun, Tzehsien, and Chinghsing districts) produces 190,000 T. of fire clay and pottery clay. Liaoning and Shantung provinces produce 100,000 T. each. H.H.S.

Concentration of Georgia kyanite ore. R. G. O'MEARA AND B. W. GANDRUD. *Mining & Met.*, **17** [350] 118 (1936).—Gravity concentration and flotation tests have been made on two varieties of Ga. kyanite ore, mica-schist and massive. The samples of schist ore contained 1 to 9% of kyanite crystals imbedded in mica and quartz, with lesser amounts of graphite, garnet, and iron oxide. The sample of massive ore contained 60% kyanite as radiating masses interlocked with quartz, mica, and corundum. Similar results were obtained on both ores. By classification and table concentration of a schist ore containing 9% kyanite, 67% of the mineral was recovered assaying 90% kyanite. Both ores and their table middlings are amenable to flotation and this process is necessary to raise the grade of the concentrates above 95% and to improve the recovery. Oleic acid, sodium oleate, and sodium silicate were suitable reagents. Graphite, when present, was floated first with pine oil. E.J.V.

Correlation of coal-seams by microspore content: I, Seams of Northumberland. A. RAISTRICK. *Trans. Inst. Mining Engrs.*, **88** [3] 142–53 (1934). A.H.E.

Enargite and plumbojarosite at Picher, Oklahoma. ALFRED L. RANSOME. *Amer. Mineralogist*, **20** [11] 799–805 (1935).—Enargite (Cu_3AsS_4) and plumbojarosite, a member of the alunite group, occur in the interesting assemblage of minerals in the lead-zinc deposits of the Tri-State District, and these are described for the first time together with other minerals that occur there. F.J.Z.

Estimating exchangeable calcium and other bases in noncalcareous soils. A. N. PURI. *Soil Sci.*, **40** [5] 383–90 (1935).—A simple method of estimating exchangeable calcium and other bases in noncalcareous soils consists in shaking a known weight of the soil with 0.1 *N* oxalic acid in *N* ammonium acetate. In this way the whole of the calcium is precipitated as oxalate, and the decrease in the concentration of the oxalate ion is equivalent to the exchangeable calcium in the soil. Under the experimental conditions described, all the exchangeable bases other than calcium pass into solution as acetates or oxalates. A known volume of the filtrate is evaporated to dryness and ignited; these bases are obtained as carbonates and are determined by titration with standard acid. G.R.S.

Facts in soil mechanics from the research laboratories. ARTHUR CASAGRANDE. *Eng. News-Rec.*, **115** [10] 320–23 (1935).—Recent research developed a new earth-pressure theory and disclosed unexpected data on the consolidation characteristics of clays and the behavior of soils subjected to shearing stresses. G.R.S.

Feldspar in Australia. ANON. *Chem. Eng. Mining Rev.*, **28**, 53–54 (Dec., 1935).—West Australia is the principal feldspar-producing state, with an output in 1934 of 1816 T., valued at $20,500. H.H.S.

Fluorspar production in China. W. H. WONG AND T. F. HOU. *China Yearbook*, **17**, 56 (1935).—Fluorspar is produced chiefly in Chekiang province and is almost all exported. The ore averages 80% fluorspar. Production is 8000 T./year. H.H.S.

Geochemistry of selenium: II. V. M. GOLDSCHMIDT AND L. W. STROCK. *Nachr. Ges. Wiss. Göttingen. Math.-physik. Kl.*, Fachgr. IV [1] 123–42 (1935); abstracted in *Chem. Zentr.*, ii, 1522 (1935). M.V.C.

Importance of the lattice structure of clays for the study of soils. C. E. MARSHALL. *Jour. Soc. Chem. Ind.*, **54** [48] 393–98 (1935).—The clays so far characterized fall into two groups: (1) the kaolin group, including kaolinite, dickite, nacrite, and halloysite, the lattice unit of which consists of one Al and one Si layer; certain nontronites, with iron in place of silicon may belong to this group; (2) pyrophyllite and the base-exchange group, including pyrophyllite, montmorillonite, beidellite, and many nontronites having Fe in place of Al. In this group the structure consists of one Al layer and two Si layers. In pyrophyllite there are no extensive replacements and the lattice units are stacked closely together; hence, there is no exchange capacity. In the base-exchange clays the lattice units are separated by spaces of variable width containing water and exchange cations. They form a single series with the following predominant replacements: Al for Si, beidellite; Mg for Al, montmorillonite; Fe for Al, nontronite. In the base-exchange clays the lattice layers carry negative charges which are balanced by mobile cations held in the comparatively wide spaces between the layers. The negative charges arise by the replacement of Al for Si and Mg for Al in the framework. The total negative charge is balanced partly by cations incorporated in the framework (non-exchangeable) and partly by the exchange cations, the relationship between the two being governed by electrical and geometrical factors. The $SiO_2:R_2O_3$ ratio is not an adequate criterion for the characterization of clay fractions. (4) The minor constituents of clays, *viz.*, phosphorus, titanium, probably form part of the lattice framework, phosphorus replacing Si and titanium replacing Al. G.R.S.

Mineral wealth of India, its present and future developments. EDWIN PASCOE. *Bull. Imperial Inst.*, **29**, No. 2 (1931); abstracted in *Indian Engr.*, **90** [9] 206; [10] 226 (1931). A.P.S.

Occurrence and origin of celestite and fluorite at Clay Center, Ohio. ROGER B. MORRISON. *Amer. Mineralogist*, **20** [11] 780–90 (1935).—A description and the origin of celestite and fluorite, together with illustrations and a bibliography, are presented. F.J.Z.

Pegmatite minerals from near Amelia, Virginia. JEWELL J. GLASS. *Amer. Mineralogist*, **20** [11] 741–68 (1935).—The variety and perfection of many of the mineral species from mica mines near Amelia, Va., have not yet been exhausted, and the reopening of the Rutherford mine and the opening of a new mine have given new opportunities for study. A total of 31 mineral species have been identified from the pegmatites near Amelia, and eight of these are described for the first time, *viz.*, chalcopyrite, phenacite, pyrolusite, topaz, triplite, bertrandite, biotite, and zinnwaldite. Chemical analyses of sericite and zinnwaldite are presented, together with tables containing name of mineral, color, optical characteristics, and occurrence. Bi, B, Be, Cu, Ge, Pb, Sn, and Zn have been found by spectrographic analyses in the minerals. The luminescence of the minerals is discussed and data are tabulated. F.J.Z.

Penetration method of measuring soil resistance. W. S. HOUSEL. *Proc. A.S.T.M.*, **35** [Part II] 472–90 (1935).—A rational formula has been developed which expresses the resistance to penetration in terms of shearing resistance or actual cohesion of the soil. The method is not designed for granular materials. R.A.H.

Replacement in filled fissure veins. B. M. SHAUB. *Amer. Mineralogist*, **20** [12] 875–80 (1935).—Metasomatic processes dealing with the replacement processes in practically solid rock are discussed. Photomicrographs showing the metasomatic relation between quartz, galena, sphalerite, pyrite, etc., are included. F.J.Z.

Selenium content of European and Japanese clay slate. E. MINAMI. *Nachr. Ges. Wiss. Göttingen. Math.-physik. Kl.*, Fachgr. IV [1] 143–45 (1935); abstracted in *Chem. Zentr.*, ii, 1522 (1935). M.V.C.

Steigerite, a new vanadium mineral. EDWARD P. HENDERSON. *Amer. Mineralogist*, **20** [11] 769–72 (1935).—A new yellow, hydrous aluminum vanadate, $Al_2O_3 \cdot V_2O_5 \cdot 6.5H_2O$, which has been named steigerite, is described. It is similar to but is not a true analogue of the iron vanadate, fervanite, and like fervanite is from the uranium-vanadium claims along the north wall of Gypsum Valley, San Miguel County, Colo. F.J.Z.

Tabulation of crystal forms and discussion of form-names. AUSTIN F. ROGERS. *Amer. Mineralogist*, **20** [12] 838–51 (1935).—There are two general methods of naming forms: (1) according to the number and shape of faces, and (2) according to the position of the constituent faces with respect to the axes of references. A tabulation of the names of crystal forms based upon the geometrical method of Federov is presented. The standardization of names of forms, as proposed by members of the Federov Institute of Leningrad and by Wherry, is discussed, but no new names are introduced. F.J.Z.

Talc and soapstone in Washington. HEWITT WILSON AND J. A. PASK. *Mining & Met.*, **17** [350] 118 (1936).—A brief historical sketch of the infant soapstone and talc industry in Washington and the distribution of those minerals throughout the pre-Tertiary metamorphic rocks of the northern part of the State is given. The preliminary study included water content of the original rock and its relation to subsequent cracking, cold compressive strength for a comparison with standard masonry units, thermal conductivity to 1300°C, color tests of powdered products for the filler trade, and firing tests of sawn block to a series of temperatures for service at high temperatures. The refractory tests included the A.S.T.M. load tests at high temperatures and the spalling and reheat tests. Three types of behavior were found, and in certain cases a good type of refractory resistance was found at temperatures below 1400°C, the melting point of the best material. The dense, interlocking, crystalline bond of the natural rock gives excellent permeability to the passage of gases and liquids and resistance to high-temperature load, but the melting of the magnesium silicate is more rapid and a more fluid melt is formed than with the common aluminum silicate refractories. E.J.V.

Thulite in New Mexico. STUART A. NORTHROP. *Amer. Mineralogist*, **20** [11] 805–807 (1935).—Thulite has been recorded in only two other localities in North America. The description of the mineral, the deposit, and chemical analysis are presented. F.J.Z.

Treatment of leucite to extract potash and alumina simultaneously. GAETANO CASTELLI. *Industria Mineraria*, (Nov.-Dec., 1934); abstracted in *Génie Civil*, **106** [18] 517–18 (1935).—Work conducted in an experimental plant showed that heating leucite ($K_2OAl_2O_3 4SiO_2$) for 6 hr. at 200°C in sea-salt solution under pressure of 12 to 14 atmospheres results in replacing K with Na in leucite. KCl is filtered off. $Na_2OAl_2O_3 4SiO_2$ is sintered with $CaCO_3$ which transforms it into $CaSiO_3$ and $Na_2OAl_2O_3$. Aluminate is leached out and $Al(OH)_3$ precipitated with CO_2 obtained from the sintering process. J.D.G.

BOOKS AND BULLETIN

Applied Geology (Géologie Appliquée). E. RAGUIN. 403 pp. Masson et Cie., Paris, 1934. Price 38 F. Reviewed in *Nature*, **136** [3451] 970–71 (1935).—This treatise on applied geology covers an outline of stratigraphical geology, materials of construction, building of tunnels and barrages, movement of underground waters, coal and oil, the study of mineral veins, and geophysical methods applied to prospecting. J.L.G.

Comprehensive Treatise on Engineering Geology. CYRIL S. FOX. xv + 392 pp., 18 plates. Technical Press, Ltd., London, 1935. Price 35s net. Reviewed in *Nature*, **136** [3451] 970–71 (1935).—The three sections of the book deal with building materials, field operations, and water supply. J.L.G.

Minerals Yearbook, 1935. U. S. BUREAU OF MINES. 1293 pp. Price $2 from Supt. of Documents, Govt. Printing Office, Washington, D. C. This third issue in a series which supersedes the two-volume annual compilation, Mineral Resources of the United States, comprises 75 chapters and constitutes a condensed library of current developments in the mineral industries. It covers the production of a hundred commercial minerals in the U. S. and abroad during the year 1934. Technical progress in the production of these minerals and their present economic position are reviewed. This volume continues the advances made in the 1934 volume and incorporates many improvements based on constructive suggestions volunteered by close observers and students of the mineral industry. An analysis of the extent of business recovery for various mineral groups is given. R. A. HEINDL

Petrography of the Igneous Rocks (Spezielle Petro-

graphie der Eruptivgesteine. Ein nomenklatur-Kompendium). W. E. Tröger. v + 360 pp. Verlag Deutschen Mineralogischen Ges. e. V., Berlin, 1935. Price (paper) 20 Rm. Briefly reviewed in *Econ. Geol.*, **30** [7] 833–34 (1935).—This is a compendium of information on the names and data (mineralogical and chemical) of igneous rocks. J.L.G.

Preliminary report on the mineral production of Ontario in 1934. W. R. Rogers and A. C. Young. *Ontario Dept. Mines Bull.* No. 98, 31 pp. (1935). A.H.E.

Structural Geology: with Special Reference to Economic Deposits. Bohuslav Stočes and Charles Henry White. Macmillan and Co., Ltd., London, 1935. Price 25s net. Briefly reviewed in *Nature*, **135** [3424], 979 (1935).—This book is adapted for the use of the mining geologist. J.L.G.

Textbook of Applied Geophysics (Lehrbuch der angewandten Geophysik—[Geophysikalische Aufschlussmethoden]). Hans Haalck. vii + 376 pp., 6 plates. Gebruder Borntraeger, Berlin, 1934. Price 24 gold marks. Briefly reviewed in *Nature*, **137** [3453] 7 (1936).—This is a comprehensive introductory text to the geophysical method of exploration. The gravimetric, magnetic, electric, and seismic methods receive equal consideration. J.L.G.

Useful Aspects of Geology: an Introduction to Geological Science for Engineers, Mining Men, Prospectors, etc. S. J. Shand. 2d ed., revised and amplified. x + 183 pp. Thomas Murby and Co., London, 1934. Price 6s. Reviewed in *Nature*, **136** [3451] 970–71 (1935).—This is an introductory type of text for nontechnical workers. J.L.G.

Chemistry and Physics

Absorption factor of the powder and rotating-crystal methods of X-ray crystal analysis. A. J. Bradley. *Proc. Phys. Soc.* [London], **47** [5] 879–99 (1935).—A method has been devised for calculating the absorption factor for the powder method. It may be used for all values of μr, where μ is the linear absorption coefficient and r the radius of the specimen. A set of data was calculated for which the absorption factor may easily be obtained for any value of μr and for any angle of reflection. The data may also be applied for the calculation of the absorption factor in the lines belonging to the order of the zero layer in the rotation photographs. L.E.T.

Active oxides: No. 92, Mutual reaction between solid materials. Gustav F. Hüttig, with experiments by Theodor Meyer, Herbert Kittel, and Suzanne Cassirer. *Z. anorg. allgem. Chem.*, **224** [3] 225–52 (1935).—The active states of the oxides in the systems CuO–Fe_2O_3 and CuO–Cr_2O_3 and the regions of their existence were determined from studies on their catalytic decomposition of N_2O. A study was also made of the changes in the magnetic properties of the following mixtures on aging: Fe_2O_3–Al_2O_3, Fe_2O_3–SiO_2, Fe_2O_3–TiO_2, Cr_2O_3–TiO_2, Cr_2O_3–Al_2O_3, Cr_2O_3–SiO_2. The changes in hygroscopicity on aging of the following mixtures were determined: MgO–Fe_2O_3, BeO–Fe_2O_3, ZnO–Fe_2O_3, Al_2O_3–Fe_2O_3, ZnO–Cr_2O_3, and CuO–Al_2O_3. For Nos. **84** and **89** see *Ceram. Abs.*, **15** [3] 106 (1936). L.T.B.

Adsorption problems. I. Traube. *Trans. Faraday Soc.*, **31** [12] 1730–39 (1935).—A close relationship was found between adsorption and flocculation. In most cases adsorption is accompanied by the formation of large flocculates of varying volume produced by the linking of the adsorbent particles through the adsorbed substances. A similar relationship between flocculation and adsorption also exists in other cases, *e.g.*, the electrolytic flocculation of colloids by ions, the coagulation of organic and inorganic substances by gelatinous colloids, and the flocculation of ores by surface active organic substances. Attention is drawn to the two constituents of the adsorption energy, *i.e.*, the capacity and intensity factors. Methods of determining the adsorption intensity are considered. G.R.S.

Adsorption theory. H. Bradley. *Trans. Faraday Soc.*, **31** [12] 1652–55 (1935).—A discussion is given of recent formulas for deriving the amount of adsorbed material. The advantages of using B.'s formula are pointed out. G.R.S.

Atomic structure of silicates. L. H. Borgström. *Finska Kemistsamfund. Medd.*, **42**, 69–75 (1933); abstracted in *Chem. Zentr.*, **ii**, 987 (1935).—According to studies of Bragg and others, the O-atoms always form the frame of silicates while Si is intercalated between 4 tetrahedral O-atoms; the position of tetrahedrons determines the silicate structure. M.V.C.

Behavior of water held in fine-pored media. B. H. Wilsdon, D. R. G. Bonnell, and M. E. Nottage. *Trans. Faraday Soc.*, **31**, 1304 (1935).—The authors describe four experimental methods for measuring the force of attraction between water and porous media. They also give experimental data on kaolin, sand, silicon carbide, and two clays, comparing the results obtained with the hydrostatic-tension, osmotic-pressure, and vapor-pressure methods. Very poor agreement is found between the results obtained with the several methods, supporting the conclusion obtained from data in the literature which indicate that the results of such determinations may be quite anomalous. The authors suggest as an explanation the possibility of molecular orientation in thin liquid films on solid surfaces and the importance of such effects on the behavior of water in fine-pored systems. G.R.S.

Changes in crystal structure and their influence on the reactivity and catalytic effect of solids. J. A. Hedvall. *Chem. Rev.*, **15**, 139–68 (1934); *Jour. Soc. Glass Tech.*, **19** [74] A131 (1935).—The effect of particle size, origin of preparations, heat treatment, and crystallographic condition of some metallic oxides on their interaction is discussed, and a critical review is presented of solid reactions and changes in the solid state.

Chemical studies of the silicates: III, Behavior of talc toward MgO and the chlorides of Mg, Co, and Mn on heating. Erich Thilo. *Z. anorg. allgem. Chem.*, **225** [1] 49–63 (1935).—The decomposition of talc and the reaction of talc with MgO, $MgCl_2$, $MnCl_2$, and $CoCl_2$ were studied in the following manner: After heating the mixtures, they were extracted with NaOH and HCl. Analyses were made of the residues. The reaction of talc with the chlorides dif-

fers from the reaction of pyrophyllite with the chlorides. In the case of the talc, only the decomposition products of the talc, $MgSiO_3$ and SiO_2, react with the metal oxides; the Mg may be replaced by metal ions. The reaction products which form are $MgSiO_3$ and $MeSiO_3$ (or solid solutions of these two) with some free SiO_2 and orthosilicate. L.T.B.

Coagulation of soil suspensions by aluminum and iron salts. Electrophoretic study. L. R. Setter and S. Mattson. *Ind. Eng. Chem.*, **27** [1] 94–97 (1935).—Using a concentration of soil colloids equivalent to 400 parts per million, it was found that the higher the percentage of iron and aluminum oxides in soils the less coagulant (aluminum chloride) was required to render them isoelectric at a given p_H. Each soil colloid can be isoelectrically precipitated over a wide range of hydrogen-ion concentration. With a minimum of coagulant the aluminum-soil complex will be isoelectric at a p_H of 4.0, and any additional quantities of coagulant will raise the isoelectric p_H ultimately to that of pure alumina. The treatment of a soil colloid with equivalent quantities of ferric chloride and of aluminum chloride shows that the soil colloid treated with ferric chloride retained a stronger negative charge and the resultant p_H was lower than the soil colloid treated with aluminum chloride. Flocculation was not as rapid or as complete at the p_H employed with ferric chloride as with aluminum chloride when small quantities were compared. Illustrated. F.G.H.

Collation of experimental data: XXIV. A. Alison. *Glass*, **12** [8] 339 (1935).—A. discusses the method of plotting data according to the group or class ratings instead of, as ordinarily done, by individuals. By this means of recording data smoother and more regular curves are produced through the elimination of many of the smaller irregularities. **XXV.** *Ibid.*, [9] 381.—A discussion of the applications of the standard deviation principle for recording certain types of data is given. Illustrated. For Parts **XXII** and **XXIII**, see *Ceram. Abs.*, **15** [1] 42 (1936). M.C.S.

Determination of plagioclase by the Federov Universal Stage. T. L. Ho. *Amer. Mineralogist*, **20** [11] 790–98 (1935).—H. describes a method which overcomes the tedious procedures involved in determining the position of orientation of feldspars, twinning, and composition. Schematic diagrams facilitate the understanding of the method used. F.J.Z.

Electroanalytical method for the determination of alkalis. Karl Abresch. *Angew. Chem.*, **49** [43] 483 (1935).—A new electroanalytical method for the determination of sodium and potassium is described. The method is satisfactory in solutions containing the cations Fe, Al, Ca, Mg, K, and Na. See also "Apparatus—" *Ceram. Abs.*, **15** [3] 106 (1936). L.T.B.

Formula for the rate of evaporation of adsorbed atoms and molecules. J. K. Roberts. *Trans. Faraday Soc.*, **31** [12] 1710–13 (1935).—A formula for the rate of evaporation of adsorbed atoms and molecules is obtained directly from simple kinetic considerations. A vapor-pressure equation is also deduced. G.R.S.

Inversion of quartz to tridymite: III, Effect of mineralizers on the inversion of quartz. IV, Influence of the amount of mineralizers on the inversion of quartz. V, X-ray analysis of silica brick which has been for a long period in open-hearth furnaces, regenerators, or tank furnaces. S. Kondo and T. Yamauchi. *Jour. Soc. Chem. Ind. Japan*, **38** [12] 730–32B (1935).—The effect of heating pulverized rock crystal and pure silicic acid at 600° to 1300°C for 5 hr. and the effect of different mineralizers on the formation of cristobalite and tridymite are given. For Parts **I–II** see *Ceram. Abs.*, **15** [3] 107 (1936). M.V.C.

Lattice dimensions of zinc oxide. C. W. Bunn. *Proc. Phys. Soc.* [London], **47** [5] 835–42 (1935).—The lattice dimensions of pure zinc oxide condensed from smoke have been determined to a high degree of accuracy by means of X-ray powder photographs. Bradley and Jay's lattice dimensions of quartz and Siegbahn's X-ray wave-length being accepted as the standards, the lattice dimensions of ZnO are found to be:

$$\left.\begin{aligned} a_0 &= 3.2426_3 \pm 0.0001 \\ c_0 &= 5.1948 \pm 0.0003 \end{aligned}\right\} \text{ at } 18°C$$

Axial ratio $c_0/a_0 = 1.6020_9 \pm 0.001$. L.E.T.

Oxide reactions and their significance for the chemico-silicate industry and slag chemistry. J. Arvid Hedvall. *Tek. Tid.*, **65** [23] 41–46 (1935); abstracted in *Chem. Zentr.*, **ii**, 3279 (1935).—A condensed review is given. M.V.C.

Photometric determination of silicon in the presence of iron and other elements. H. Pinsl. *Arch. Eisenhüttenwesen*, **9**, 223–30 (1935).—This determination is carried out without precipitation of phosphate and without filtration. An addition of sodium fluoride is made after the molybdate reaction. W.M.C.

Quantitative measurement of the intensity of X-ray reflections from crystalline powders. J. C. M. Brentano. *Proc. Phys. Soc.* [London], **47** [5] 932–47 (1935).—B. refers to determinations of the dispersion of *F*-values in the range of the *L*-absorption levels, in which powder methods were applied to measurements requiring a high degree of accuracy, and discusses the condition determining quantitative measurements made with microcrystalline powders, etc. A detailed discussion is given of the factors determining qualitative measurements by the method of the flat powder layer and by the method of mixed powders. L.E.T.

Quartz paramorphs after tridymite and cristobalite. Robert S. Moehlman. *Amer. Mineralogist*, **20** [11] 808–10 (1935).—In the area described, indications point to the inversion of tridymite and cristobalite to quartz, facilitated by the presence of alkaline waters carrying silica. F.J.Z.

Rapid detection of potassium and sodium in the presence of ammonium and magnesium. C. Candea and L. I. Sauciux. *Bull. Sci. École polytech. Timisoara*, **5**, 111–13 (1934); abstracted in *Chem. Zentr.*, **ii**, 2555 (1935).—K and Na must be present as chlorides. NH_4 and Mg are determined as usual. The residue of the solution is carefully and slowly evaporated to dryness. K is determined with Na-acetate and tartaric acid and Na with K-pyroantimonate containing KOH in a watery extract of the melt. M.V.C.

Rapid method of analysis of glass sand. Michel B.

VILENSKY. *Jour. Amer. Ceram. Soc.*, **19** [3] 91–92 (1936).

Recent revisions of high temperatures. H. T. WENSEL. *Jour. Amer. Ceram. Soc.*, **19** [3] 81–86 (1936).

Separation of iron and aluminum from alkaline earth metals with ammonia. MATEJ FERRICH. *Bull. Soc. Chim. Yougoslavie*, **6**, 27–50 (1935); abstracted in *Chem. Zentr.*, ii, 2850–51 (1935). M.V.C.

Solubility in sulfuric acid of minerals containing titanium. J. N. BOGOYAVLENSKIĬ AND B. J. BOGUSLAVSKIĬ. *Za lakokrasochn. Ind.*, **3**, 20–24 (1934); abstracted in *Chem. Zentr.*, ii, 1761 (1935).—The effect of the H_2SO_4 concentration, temperature, and duration of the dissolving of Ti present in ilmenite was studied. M.V.C.

Sorption of liquids by soil colloids: II, Surface behavior in the hydration of clays. L. D. BAVER AND HANS WINTERKORN. *Soil Sci.*, **40** [5] 403–19 (1935).—A study was made of the influence of the structure of soil colloids and of the amount and nature of ions at the surface on such colloidal properties as sorption of liquids, heat of wetting, viscosity of suspensions, zeta-potential of the dispersed particles, hygroscopicity, and hydration. On the basis of these experimental data, hydration is explained as being due in the largest degree to the orienting influence on dipole molecules of the colloid surface as well as of the adsorbed cations. With special colloids (bentonites and alkali-saturated organic matter) an osmotic type of swelling seems to play a significant rôle. The importance of the shape of the primary and secondary colloidal particles on the evaluation of swelling from sorption data is stressed. The principal swelling theories are briefly discussed in their relation to the data and conclusions of this particular study. For Part I see *Ceram. Abs.*, **14** [2] 49 (1935). G.R.S.

System iron–cementite–manganese carbide–manganese. R. VOGEL AND W. DÖRING. *Arch. Eisenhüttenwesen*, **9**, 247–52 (1935).—Phase equilibria of this system and the system manganese–manganese carbide were derived. A new change of modification for manganese carbide was observed at 1050°C. Four planes with four phases each occur, because of the transformations of manganese and manganese carbide. Three of these planes are transformation planes and the fourth corresponds to a ternary eutectic composition. W.M.C.

Why not "calcia"? M. E. HOLMES. *Bull. Amer. Ceram. Soc.*, **15** [2] 53 (1936).

PATENTS

Method of making titanium dioxide. R. H. MONK AND A. S. ROSS (American Zinc, Lead & Smelting Co.). U. S. 2,028,292, Jan. 21, 1936 (July 12, 1934).

Method for producing titanium dioxide. W. T. LITTLE (American Zirconium Corp.). U. S. 2,029,881, Feb. 4, 1936 (April 23, 1934). In a process for preparing titanium dioxide, the step comprises hydrolyzing a titanium salt solution by heating in the presence of a solid alkali titanate.

Preparation of calcined titanium oxide pigments. TITAN CO., INC. Brit. 440,611, Jan. 15, 1936 (May 19, 1934).

Process of manufacturing soluble salts of barium and strontium. R. N. SHREVE, W. N. PRITCHARD, JR., H. V. FARR, A. J. STILL, AND J. D. CROSBY (Mallinckrodt Chemical Works). U. S. 2,030,659, Feb. 11, 1936 (Dec. 10, 1934). The process of manufacturing soluble salts of barium or strontium comprises treating barium or strontium sulfate with a salt of the type MX, where M represents a basic radical selected from a group composed of calcium, magnesium, and aluminum, and X represents an acid radical capable of forming, with barium or strontium, the desired soluble salt, in such a manner that a double decomposition reaction takes place, forming a mixture of the sulfate of M and the X salt of barium or strontium, and thereafter extracting the reaction mixture with a solvent which does not substantially reverse the reaction and which selectively dissolves the X salt of barium or strontium but leaves the sulfate of M substantially undissolved.

Process for producing practically iron-free compounds of the earth metals, alkaline earth metals, rare earth metals, earth acids, etc. GUSTAV JAEGER (Deutsche Gold und Silber Scheideanstalt vorm. Roessler). U. S. 2,030,372, Feb. 11, 1936 (Nov. 5, 1934). A process for the removal of iron from iron-containing raw materials comprises the steps of reducing the valence of the iron, treating with a cyanide, adding water, separating any insoluble matter which may be present at this point, and adding an alkaline reagent to precipitate as hydroxides all cations in the raw material which have the property of forming insoluble hydroxides in the presence of alkaline cyanide, the iron in combination with the cyanide forming a complex water-soluble ferrocyanide and removing the insoluble hydroxides.

General

Cinder and dust elimination at the Washington heating plant. F. P. FAIRCHILD AND C. F. DIXON. *Combustion*, **7** [2] 13–16 (1935).—This two-stage system consists of a cinder trap to remove the coarser particles and an electrostatic precipitator to remove the fine particles. Tests over a wide range of coal-burning rates on the stokers showed efficiencies for the system from 89.2 to 94.9%. H.E.S.

Industrial America, its way of work and thought: X, Modernizing the building industry. ARTHUR POUND. *Atlantic Monthly*, **156** [4] 505–12 (1935).—P. thinks that lack of stability and cohesion within this industry is the chief difficulty and that this flows directly from relative inability to think in terms of the ultimate consumer. For years Johns-Manville Corp. has been financing studies and surveys on the history and economics of building, the needs and desires of consumers, and the complex trade factors which create the sad lag between the potential desire for home creation and the shrunken materialization of that desire. The Corporation's point of view toward construction is presented. See also this issue, p. 111. A.P.

Maintenance organization and management. L. C. MORROW. *Factory Management & Maintenance*, **93** [12] S149–64 (1935).—M. considers (1) what maintenance is, (2) jobs and personnel, (3) maintenance order forms, (4) maintenance control by costs, (5) maintenance on incentive, (6) yardsticks for maintenance, and (7) equipment, tools, and supplies. Illustrated by graphs and forms. J.L.G.

Patent law for engineers. L. T. PARKER. *Combustion*

7 [2] 34–35 (1935).—P. answers some questions as to ownership of patents by employee or employer and gives specific suggestions that should aid the inventor in protecting his claims through maintaining complete records of his work, filing at the proper time and in proper form, and including a complete description. Decisions of the courts are cited to cover the points discussed. H.E.S.

Röntgenological observations regarding pulmonary silicosis in porcelain workers. G. JÖNNSON. *Acta Radiol.*, **16**, 431–38 (1935); abstracted in *Ind. Hyg. Abs.*, **17** [5] 101–102 (1935).—This article is confined to certain X-ray considerations in cases of silicosis. It is based upon an examination of 236 porcelain workers, but no statement is made as to exposure to dust of these men or of the extent to which their health is injured by their occupation. The main point is to draw attention to the need for lateral X-ray examination of the chest as well as frontal, in order to detect the displacement which takes place when fibrous tissue in the lungs contracts. The contractions involve the posterior inferior portion of the upper lobes and the posterior superior portion of the lower lobes, and the centers of contraction are situated superiorly, posteriorly, and laterally. The trachea is drawn back, so that the bifurcation may lie almost immediately in front of the vertebral column. The bronchi and vessels are drawn to the side. These changes, which are not to be seen in frontal examination, embarrass the passage of air and the blood circulation and so contribute to the dyspnea of silicosis. E.J.V.

Selection and design of equipment for burning Illinois coal. H. KREISINGER. *Combustion*, **6** [12] 29–33 (1935).—The physical properties of Ill. coal are reviewed and the types of fuel-burning equipment and furnace arrangements best suited to meeting these conditions are discussed. Typical furnace designs for both traveling-grate stokers and pulverized coal are included. H.E.S.

Silicosis from the standpoint of the mineralogist. H. UDLUFT. *Zentr. Gewerbehyg. Unfallverhüt.*, **22** [May-June] 81–87 (1935); abstracted in *Ind. Hyg. Abs.*, **17** [6] 130 (1935).—U. shows the need for coöperative work in the fields of mineralogy and medicine in studying silicosis. He has summarized the physical and chemical properties of the silicosis-producing minerals and rocks and gives a list of 18 minerals, most of them silicates, which are needle-shaped like sericite. Silica is not completely insoluble, especially in the alkaline fluids of the body; solubility figures, however, are not available. The high body temperature increases the reaction velocity over that at room temperature. In view of these facts, U. believes that formation of hydrosilicates such as sericite from the inspired dust can take place in the lungs. E.J.V.

Silicosis and tuberculosis; experimental studies on the action of pure amorphous silica and of crystalline silica (quartz) on tubercular guinea pigs. H. SELTER AND P. WEILAND. *Zentr. Gewerbehyg. Unfallverhüt.*, **22** [Jan.–Feb.] 12–34; [March–April] 61–74 (1935); abstracted in *Ind. Hyg. Abs.*, **17** [5] 102 (1935).—Dusting chambers somewhat like Jötten's were used with dusts of known particle size and composition. Concentrations were of the order of 50 to 100 mg./cu. m. with less than 1% of the particles over 20μ and 60% below 2μ. Dusting was carried out for 8 hr. daily for a time varying from 2 to 7 months. Three distinct parts of the dusting experiments were studied: (1) action of the dusts on normal guinea pig's lungs, (2) their effect on primary tuberculosis infections, and (3) their effect on secondary tuberculosis infections. The amorphous silica inhalations caused no demonstrable silicosis while the quartz dusts gave the expected reactions. The dusted animals apparently did not succumb to a tubercular infection while those already infected were apparently not adversely affected by subsequent dusting. E.J.V.

Symbols, units, and nomenclature. G. W. O. HOWE. *Sci. Progress*, **30**, 268–71 (Oct., 1935).—The latest definitions in heat, electricity, and magnetism are discussed. H.H.S.

Unusual boiler scale. L. B. MILLER. *Combustion*, **6** [11] 13 (1935).—Boiler scales consisting chiefly of magnesium hydroxide, although not unknown, are somewhat rare. Scale characteristics and a photomicrograph are presented. H.E.S.

Western Society of Engineers. ANON. *Jour. West. Soc. Engrs.*, **40** [5] 180–248 (1935).—The object, activities, and membership grades are outlined. The engineering building, meeting rooms, and officers are shown. J.L.G.

What every boiler operator should know about superheaters. J. WAITKUS. *Combustion*, **6** [12] 16–19 (1935). H.E.S.

When the power load grows: I–II. A. G. CHRISTIE. *Combustion*, **6** [12] 11–15; **7** [1] 13–19 (1935).—General problems connected with the future growth of power load and means for meeting such an increase are presented. Plant equipment necessary for an increased load and possible developments in machines are also discussed. H.E.S.

Why don't college graduates stay educated? CHRISTIAN GAUSS. *Bull. Amer. Ceram. Soc.*, **15** [2] 52 (1936).

NEW JOURNAL

Acta Physicochimica U.S.S.R. Vol. I, No. 1, Sept., 1934. 182 pp. Editorial office Malaya Pirogovskaya 1, Moscow 21, U.S.S.R. This new scientific periodical printed in foreign languages is published to acquaint the foreign scientists with the rapid progress of physical chemistry in the U.S.S.R. Four large research institutes, a number of special chairs in various higher schools, and several physicochemical departments at various research institutes were established with the aim of furthering the theoretical and applied sciences. To coördinate research work in this field an Association of Physico-Chemical Institutes was organized in 1932. The first number contains nineteen original papers. S. I. PERKAL

BOOKS

A.S.T.M. Tentative Standards, 1935. ANON. Published by Amer. Soc. for Testing Materials, Philadelphia, Pa. 1591 pp. Price $8.00. The 1935 edition gives in their latest approved form 290 tentative standards, providing specification requirements, methods of testing, definitions, and recommended practices covering widely used materials of engineering. R. A. HEINDL

Chimneys and Flues: Domestic and Industrial. PERCY L. MARKS. 131 pp. Technical Press, Ltd., London, 1935. Price 4s net. Briefly reviewed in *Nature*, **137** [3453] 6 (1936).—This is a short treatise on chimney-flue

construction and the common types of trouble from down drafts. J.L.G.

Handbook of Ceramics (Manual de Cerámica). JUAN VIDAL Y MARTIN. Espasa-Galpe, S.A., Madrid, 1934. 280 pp., 90 figs. Price about 75¢. This Spanish handbook explains and pictures machinery and equipment (including kilns) for the manufacture of clayware, and describes the methods in vogue in Spain and a few other European countries, going to a certain extent into the fundamentals of clayworking, taking up the making of brick, tile, and pottery, and giving batch compositions, coloring oxides, etc. Chapter headings and subheadings are as follows: (1) Raw materials (plasticity, nonplastics, fluxes), (2) Treatment (clays, nonplastics, fluxes), (3) Preparation and tempering, (4) Making (shaping, drying), (5) Firing (fuels, kilns, pyrometry, etc.), (6) Common ware (brick, roofing tile, crockery, pipes, artware), (7) Refractories (brick, crucibles, pots, retorts, kiln furniture), (8) Earthenware (materials, glazed ware, coarse earthenware, fine earthenware, construction ware, and artware), (9) Stoneware (common ware, fine ware, architectural ware), (10) Porcelains (feldspar, fritted, phosphorus, magnesium, and porcelain for buttons and artificial teeth), (11) Decorating (colorants, glazes, technique, underglaze colors, enamels, overglaze colors). T. W. GARVE

Index to A.S.T.M. Standards and Tentative Standards. ANON. Published by Amer. Soc. for Testing Materials, Philadelphia, Pa., 1936. 160 pp. The 504 A.S.T.M. standards and 290 tentative standards in effect as of Jan., 1936, are indexed under appropriate key words.

R. A. HEINDL

Memorandum Book for Glass, Ceramics, Enameling, Cements (Agenda pour Verrerie, Céramique, Emaillerie, Cimenterie). JACQUES WOLF. Edition Universelle, Bruxelles, 1935. 316 pp. In the second year of its issue, the "Agenda" maintains the general plan of the first (*Ceram. Abs.*, **13** [7] 196 (1934)) but sections dealing with cements and furnaces are added. The list of publications devoted to silicate and allied industries is not complete. Misprints are present, *e.g.*, on p. 271, cadmium silicate instead of calcium silicate. At 2200°C silicon carbide does not melt but dissociates. It is recommended that the technical tables be revised in the next edition.

S. I. PERKAL

Municipal Smoke Problem. H. H. MELLER AND L. B. SISSON. Mellon Institute of Industrial Research, Pittsburgh, 1935. 20 pp. This brief treatise on the products of combustion of fuels and their effects was published in response to a request made by the General Science Club of teachers in the Pittsburgh High Schools. The authors give information and advice for choosing new equipment and for the selection of fuel and the best method of burning it to secure efficiency and practical smokelessness.

H. E. SIMPSON

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American Glass Review
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Glashütte
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Glass Industry
Glastechnische Berichte
Grits and Grinds
Industrial and Engineering Chemistry
Industrial Heating
Industrial Standardization
Journal of the Canadian Ceramic Society
Journal of the Indian Ceramic Society
Journal of the Institute of Metals
Journal of the Iron and Steel Institute
Journal of Research of the National Bureau of Standards
Journal of the Society of Chemical Industry, Japan
Journal of the Society of Glass Technology
Journal of the Western Society of Engineers
Keramika i Steklo
Keramische Rundschau
Keramos
Metal Progress
Metals and Alloys
National Glass Budget
Official Gazette of the U. S. Patent Office
Official Journal (British Patents)
Ogneuporui
Ohio State University Engineering Experiment Station News and Bulletin
Physics
Pottery Gazette
Quimica e Industria
Referatkartei der Silikatliteratur
Refractories Journal
Revue de matériaux de construction et de travaux publics
Review of Scientific Instruments
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Rock Products
Sands, Clays, and Minerals
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Transactions of the American Foundrymen's Association
Transactions of the Ceramic Research Institute (Leningrad)
Transactions of the Ceramic Society (English)
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Ukrainian Chemical Journal
Verre et Silicates Industriels
Zprávy Československé keramické společnosti

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